AGRICULTURE CANADA'S SUBMISSION

TO THE

NORTHERN DISEASED BISON ASSESSMENT PANEL

NOVEMBER 17, 1989

91-06258/

AGRICULTURE CANADA SUBMISSION to the NORTHERN DISEASED BISON ENVIRONMENTAL ASSESSMENT PANEL

NOVEMBER 17, 1989

TABLE OF CONTENTS

PAGE

A. Background 1

B. Response to Panel Information Requests 5

C. Proposed Course of Action 20

- C.1 Introduction 21
- C.2 Management Plan 23
    - C.2.1 Plan Hi-lites 23
    - C.2.2 Disease Eradication 25
    - C.2.3 Replacement with Wood Bison 27
    - C.2.4 Timetable 29
    - C.2.5 Costs - Yearly Breakdown 31
- C.3 Prevention of Environmental and Social Problems 34
- C.4 Will the Plan Work? 41
- C.5 Advantages and Disadvantages 45

D. Summary and Conclusions 49

E. Glossary 50

F. Appendix I - Critique of Buffer Zone, Fencing, Composite, and Status Quo Options 54

G. Appendix II - Transmission of Bovine Brucellosis and Tuberculosis from Bison to Cattle 64

H. Appendix III- Synopsis and Literature: Zoonotic Aspects of Brucella abortus and Mycobacterium bovis with Special Consideration of the Reservoir of brucellosis and tuberculosis in bison in and around Wood Buffalo National Park 67

A. BACKGROUND

Agriculture Canada has been asked by the Northern Diseased Bison Assessment Panel to be the Proponent of a course of action which it produced in consultation with several other agencies. This plan had been submitted to the Panel in September, 1989. The Panel also requests that it be given additional information to this. The following document does this and incorporates the original plan revised to clarify several matters.

The submission is organized in an attempt to provide information in a logical and clear manner. It begins with a background which gives a brief global picture of the situation at this time. This is followed by section "B" which contains the detailed responses to the Panel's information requests specific to Agriculture Canada. Section "C" of the document consists of the proposed course of action.

Section "C" is organized into several parts. The first section outlines the plan itself including the timetable and predicted costs. The latter sections give details on preventing negative environmental and social problems. There is a section which deals with the feasibility of the plan itself and a final part that discusses the advantages and disadvantages of the plan.

The final section of the document "D" provides a summary and conclussion to the submission.

The Issue:

The introduction of plains bison into Wood Buffalo National Park in the 1920s resulted in a general hybridization of the bison as well as introduction of bovine tuberculosis and probably brucellosis. It is estimated that up to 50% of the approximately 4200 bison which now inhabit the Park and vicinity are infected with one or the other of the diseases.

In recent years, mixed agriculture has moved closer to the Park along the Peace River Corridor. Game farming, private herds of livestock, and the establishment of grazing leases in the area are increasing the probability that one or both of these diseases will be transmitted from bison to domestic animals.

Disease Status of the Canadian Cattle Herd:

Agriculture Canada, through the disease eradication program has worked to eradicate both of these diseases from the national cattle herd. Canada was declared free from bovine brucellosis in 1985 and is predicted to be free from bovine tuberculosis in 1990. It was estimated in 1978 that failure to control and eradicate these diseases from the national cattle herd would result in a cumulative economic loss to Canada of $1 billion in the following twenty years. This is from clinical disease in the cattle population and loss of important international markets as a result of a downgrading of the national disease status.

The introduction of disease and the hybridization of the wood buffalo has created two immediate problems:

(i) the free-roaming hybrid bison in and around WBNP are infected with the reportable diseases of tuberculosis and brucellosis and, as a result, may spread these diseases to livestock, other wildlife including the endangered wood bison, and man;

(ii) these diseased hybrid bison pose a threat to the health and genetic integrity of the wood bison of the Mackenzie Bison Sanctuary or other free-roaming wood bison herds that may be established in the area.

Agriculture's Proposal:

Agriculture Canada, in consultation with other agencies, has developed a plan to eradicate the diseases of bovine brucellosis and tuberculosis from Wood Buffalo National Park and vicinity which presently infects up to 50% of the resident hybrid bison.

Fundamental to the success of this plan is the removal of all bison in the area which are either diseased or exposed to disease. The proposal includes the replacement of the depopulated hybrids with wood bison.

Agriculture Canada's objective in this is to eliminate transmission of diseases to domestic livestock and the perception of its possibility. This is related to the overall objectives of the Food Production and Inspection Branch which in essence is mandated to:

- control or eradicate "Reportable Diseases" in animals as specified by the Animal Disease and Protection Act

- ensure a safe and wholesome supply of meat and poultry products for trade between provinces and for export to other countries;

- carry out research into animal diseases;

- provide diagnostic and other services; and
- to manufacture diagnostic agents for use in eradicating diseases

Search for a Solution:

In 1986 an inter-jurisdictional Steering committee was formed to discuss the national implications of tuberculosis and brucellosis in bison in the Wood Buffalo National Park area. This committee is composed of representatives from Agriculture Canada, Canadian Parks Service, Canadian Wildlife Service, Health and Welfare, N.W.T. Dept. of Renewable Resources, Alberta Agriculture, And Alberta Forestry Lands and Wildlife.

The steering committee formed a Task Force to review existing information and consider possible options. The task was difficult in that each of the agencies wants a solution that meets its particular objectives. The task force finished their work, and produced a report, "Evaluation of Brucellosis and Tuberculosis in Northern Canada".

This issue has now been referred to an Environmental Assessment Review Panel to publicly review and assess possible solutions and their potential impacts.

Four options have been distilled from the task force's report. Agriculture Canada has reviewed each and embraced one as being that which meets all its objectives. It also seems to meet as well the objectives of the other concerned agencies.

These include the objectives: to eliminate any possible transmission of the diseases to domestic livestock; to prevent disease and genetic contamination of the wood bison and reintroduce these animals into their historic range; to insure a viable and self sustaining population of bison in WBNP; to ensure that people hunting and handling bison are protected from contracting bovine brucellosis or tuberculosis.

The options:

Current Status:

This option would see a disease encumbered bison population in the Park and the continued threat of disease transmission forever. Present precautions to prevent the spread of the disease into other susceptible populations would need to be continued and strengthened. The benefits that can be envisioned if the diseases were totally eradicated are in jeopardy. If the efforts to contain the disease fails even partially, large setbacks will occur and irreversible damage may result.

Interim Protection Measures:

Agriculture Canada is maintaining a surveillance program in the auction markets of northern Alberta. This will continue until the disease threat is eliminated. Routine area testing of herds in the vicinity of the Park will also have to continue to be maintained.

Disease Containment:

This option would need to be incorporated into any consideration given to retaining the current status. The disadvantage of adopting either the current status or a disease containment option is that it must be envisioned for perpetuity. Any breach of such containment at any time in the future, will result in disease spread to susceptible populations.

Costs of disease containment here will never cease and will in time overrun any proposals to eradicate the disease. As other disease free populations expand the costs of infection to them and the difficulties of bringing them back to disease free status will only increase.

Disease Eradication:

The option of choice. It is attainable, and once reached, allows for the propagation of bison in and around the Park, without any encumbrances of these two infectious diseases. Agriculture Canada presents herein a proposal which will achieve this. This proposal provides for the entire depopulation of the infected and disease- exposed bison in the Park, and their replacement with disease- free wood bison from surpluses produced at Elk Island National Park and the Mackenzie Bison Sanctuary, as well as from proposed bison ranching enterprises.

The added benefit of this proposal is the opportunity to reintroduce wood bison into their historic range.

B. RESPONSE TO PANEL INFORMATION REQUESTS

INTRODUCTION

Agriculture Canada's response to the Northern Diseased Bison Environmental Assessment Panel's request for information concerns actions that may be taken under the authorities of the Animal Disease and Protection Act and Regulations or the Meat Inspection Act and Regulations.

Brucellosis and tuberculosis are reportable diseases under the Animal Disease and Protecion Act and when reported in animals (domestic or wild) the Department is required to investigate and to take action in line with policies established and with resources available. The Meat Inspection Act and Regulations specify standards for the humane slaughter of animals and for the inspection of meat for interprovincial/territorial sale and for export of meat to other countries.

The responses are consistant with departmental goals:

- to eradicate bovine brucellosis from all animals in Canada and to maintain Canada's animal resources free from this disease,
- to eradicate bovine tuberculosis from all animals in Canada and to maintain the free status once it is established,
- to ensure that meat inspected for consumption by Canadians and for export markets is wholesome and safe.

RESPONSES

Nubered sections given below are used in the Panel's request document.

3.0 Current Status

3.1 If the current status is maintained (ie. the existing free-roaming herd remains in the area), what specific measures will your agency implement to reduce or eliminate risk to people, cattle, domestic bison, and other wildlife from:

i) Disease Transmission

If the current status was to continue, Agriculture Canada would implement a number of actions to prevent, detect and eradicate any transmission of bovine brucellosis or bovine tuberculosis to domestic livestock or game ranched wild species. Agriculture Canada would also assist other agencies in protecting free-roaming wildlife from exposure to these reportable diseases.

a) **Prevention Measures**

Agriculture Canada would advise Alberta and Northwest Territories authorities that known infected free-roaming bison outside Wood Buffalo National Park would be subject to depopulation measures. Agriculture Canada would start action to implement the initial assessment phase of an Environment Assessment and Review Process as it may apply to depopulation of the infected Slave River lowlands herd and the Wabasca and Fire Bag herds in Alberta.

b) **Detection Measures**

Agriculture Canada would continue current brucellosis surveillance programs in livestock markets in Northern Alberta and would continue the implementation of the brucellosis and tuberculosis testing programs for captive wild ungulates (bison, deer and elk). The latter program will be applied to the bison ranch east of Fort Vermilion, Alberta, and bison ranching activities proposed for the Slave River lowlands area. Brucellosis testing in Alberta federally inspected abattoirs and brucellosis and tuberculosis surveillance testing in all federally inspected abattors across Canada would be continued indefinitely.

If significant transmission to the national cattle herd was detected, national livestock market surveillance would be re-introduced. A program of annual testing of all cattle and domestic bison north of Manning, Alberta, would be implemented as long as the infected Wood Buffalo Park herd remained a risk.

c) **Eradication Measures**

When either brucellosis or tuberculosis is detected in any herd of animals in Canada, the herd is depopulated and all exposed animals are traced and slaughtered. Since 1974, 1028 cattle herds and three bison herds have been depopulated and replaced with livestock free of both diseases.

3.2: Assess the effectiveness of each measure identified in sections 3.1, and rate the probability of success.

a) **Prevention Measures**

The elimination of known diseased bison herds outside WBNP would reduce the risk of transmission of the two diseases to cattle and bison herds outside the Park and would reduce the risk of spread to native people who harvest animals from these herds. The probability of successfully preventing transmissions over the longer term is low because it is predicted that animals will continue to stray from the Park on an ongoing basis.

Surveillance testing to detect any transmission would not do anything to prevent the actual spread from the diseased bison to cattle or domestic bison but early detection would permit eradication before infection became widespread in the national cattle herd.

Because of its close proximity, these measures will have little effect on reducing the risk of spread to the wood bison herd in the Mackenzie Bison Sanctuary. The probability of spread to that herd will remain high and is rapidly increasing due to the good reproductive rate and the continuing expansion of the brucellosis and tuberculosis free herd.

3.3: What are the estimated ongoing costs (to government, industry, and the public) associated with each of the protection measures identified in section 3.1?

a) Prevention Measures Costs

Estimated costs of depopulating 400 NWT bison (Slave River lowlands) and 175 Alberta bison (Wabasca and Fire Bag herds) is $795,000 based on Department of Environment estimated costs of $1,382 per animal (page 72, Compendium of Government Submissions).

b) Annual Detection (Surveillance Testing) Costs

Alberta Livestock Markets	$ 355,000
National Livestock Markets	1,500,000
Alberta Registered Establishments (abattoirs) Brucellosis testing	205,000
T.B. and brucellosis testing in Registered Establishments outside Alberta	504,000
Testing of cattle entering and leaving Fort Vermilion Grazing Lease	12,600
Testing of cattle and bison north of Manning, Alberta	33,075
Total	$ 2,609,675

c) **Eradication Costs**

The cost of eradicating detected brucellosis or tuberculosis is variable depending on the size and the nature of infected herds. The average cost to Agriculture Canada of eradication in the four most recently depopulated herds was $185,000 per herd.

The ongoing costs of these measures to the livestock industry are related to the need to provide facilities and the time and labour involved in presenting animals for testing. Cattle farmers and bison ranchers are required to build handling facilities costing thousands of dollars. The labour and veterinary fees associated with rounding up and testing for brucellosis and tuberculosis costs approximately $15.00 per animal.

3.4 **What are the estimated costs if the proposed protection measures fail? Include social and economic costs appropriate to the mandate of your agency, associated with:**

3.4.1 Disease transmission to domestic cattle and bison

The costs to the farmer would have to be dealt with on an individual basis because of difference in the quality of animals and the type of operation. However, example situations can be considered. Quarantine following herd depopulation and before herd replacement is enforced for 30 days. The cost of lost milk production in a 100 cow herd would be $70,800.

The costs to the consumer, especially in a small outbreak, would be negligible because they would be spread out over the total population.

The costs to the agricultural industry would be of two basic types. Direct costs to the industry would include loss of markets, reduced supplies of non exposed breeding stock, fluctuation in prices because of depopulation of animals and concern about the disease. Secondly, there would be indirect costs to the livestock industry related to public perceptions as to the wholesomeness and safety of meat products, and there would also be issues related to the acceptability of infected animals for slaughter at meat plants.

The ongoing threat posed by the infected bison in Northern Canada would inflict a substantial cost on the industry. If not removed, brucellosis and tuberculosis testing of exported breeding cattle would not be eliminated by importing countries. The ongoing cost of this testing to Canadian producers is estimated at $2.5 million per year based on exports of 50,000 cattle in 1988.

The effect on international markets would be substantial. The direct losses from a major outbreak are estimated to be up to one half of sales over a period of 10 years. This would be in the range of $75 to $100 million. Losses of beef cattle sales to the U.S. market based on decreased revenues of only 1 - 3% would be in the order of $200 to $500 million over a ten year period (L. Quantz, page 288, Compendium of Government Submissions and Technical Specialist Reports).

One of the government costs is in compensation paid to owners whose cattle are ordered slaughtered. The Animal Disease and Protection Act and Regulations specify the maximum amounts that can be awarded for cattle destroyed for bovine brucellosis and tuberculosis. The present maximum for purebred dairy or beef cattle is $1800 and $1500 respectively and for grade dairy or beef cattle is $1200 and $1000 respectively. During the 1970's when brucellosis was endemic, total compensation paid to all affected livestock owners varied between $5 million and $10 million per year.

The federal government also pays the transportation costs of cattle ordered slaughtered. This cost will vary depending on the distance from the infected farm to a federally inspected abattoir willing to accept the cattle. In addition, most federally inspected establishments charge a kill fee when cattle are sent to slaughter under license. The kill fee ranges from $50 to $100 per animal and is paid by the federal government.

Four outbreaks of brucellosis have been detected since 1985. All were due to latently infected animals. The average cost of investigating and depopulating the involved herds was $185,000. This does not include substantial loss of income by the affected producers. During the latter years of brucellosis eradication, total surveillance and eradication costs averaged $13 million to find and deal with each of the few remaining infected herds.

3.5 Identify any negative impacts that presence of the diseases may have on the development of tourism, the agriculture (cattle ranching), game ranching, and any other local industries.

The presence of brucellosis and/or tuberculosis in cattle would effectively stop all movement of cattle in and out of the region affected. It would result in quarantine of suspect herds and depopulation of infected herds. It would also curtail the export of semen and embryos from the area. Restricted movement of animals would adversly affect auction markets in the area. The diseases would not only affect cattle, but other livestock such as swine (in the case of tuberculosis). The presence of brucellosis and tuberculosis in livestock in the area would also have an indirect adverse effect on the industry because of public perception as to the safety and wholesomeness of meat products and other animal products produced in that area.

The occurrence of brucellosis and tuberculosis in game farmed animals would lead to the same negative impacts as those pertaining to conventional livestock species.

Because of public concern over transmission of diseases from wild bison to domestic bison, there would be concern over the safety and wholesomeness of bison products which could negatively impact the bison industry as a whole and the game farming industry in general. It is now in an important growth phase. The occurrence of diseases would also harm the slaughter industry, since there is a stigma attached to the handling and marketing of animals by meat plants when herds are suspected of being infected with brucellosis or tuberculosis.

4.0 MANAGEMENT ACTIONS

The following questions related to management actions are intended to provide the Panel with details of how such actons would be put into operation and what implications may arise. Although several options are discussed in a general sense in the Diseased Bison Task Force Report, the Panel requires a greater level of detail (particularly in terms of program implementation) in order to make an informed judgement on the feasibility and appropriateness of various management actions.

In answering the following questions, each agency should address any implications to their regulatory responsibilities. Each agency should also outline how they might involve members of the local communities in bison management.

4.1 Interim Protection Measures

4.1.1 What interim risk reduction measures will your agency adopt during the implementation of a disease elimination program to protect people, domestic cattle, bison and other wildlife from disease transmission and to prevent genetic contamination of wood bison? For the measures identified, specify locations where and times when such interim protection measures may be required.

Agriculture Canada will maintain current brucellosis survellance testing procedures in livestock markets in northern Alberta and brucellosis survellance testing and tuberculosis surveillance of cattle slaughtered in federally inspected establishments (abattoirs) across Canada until the disease threat from the diseased bison in and around WBNP is eliminated. These surveillance and eradication activities would be expanded as described in 3.1 depending on the length of time required to implement an effective long term plan. Interim protection would be provided by ensuring early implementation of depopulation programs for small herds and individual animals which are found outside the Park in the direction of agricultural settlements and to the north in the direction of the Mackenzie Bison Sanctuary.

4.1.2 Assess the effectiveness of each interim measure, and rate the probability of success.

The effectiveness of interim measures are described in 3.2.

4.1.3 What are the estimated costs associated with each of the interim protection measures identified?

The costs of the various measures were described in 3.3. At a minimum, they would include a one time expenditure of $795,000 to remove the estimated 575 disease exposed bison outside the Park and annual surveillance costs of $355,000 in Northern Alberta Livestock Markets and $709,000 for surveillance testing in federally inspected establishments in Alberta and across Canada.

4.2 Disease Containment

4.2.1 Would your agency's management actions identified in section 3.1 be altered by containment (by fence or buffer zone) of the diseased hybrid herd? Include the effects of containment on the level of risk and costs of management actions.

As indicated in previous responses, 3.1; 3.2, the effectiveness of surveillance of the cattle population would be low in terms of preventing transmission of bovine brucellosis and/or tuberculosis from the infected, free ranging hybrid bison to cattle.

Agriculture Canada's surveillance programs are more specifically tailored to detecting the transmission of bovine brucellosis and/or tuberculosis from infected cattle to other cattle populations.

4.3 Disease Elimination

4.3.1 Feasibility and Cost Considerations

4.3.1.1 What is the feasibility of isolating and maintaining a captive disease-free hybrid bison herd? Identify alternative means of carrying this out. What are the costs associated with each option? Who would be responsible and and involved? What criteria would be applied to certify that a herd is disease-free (considering potential for disease latency)? For what purpose(s) might individuals be salvaged (include potential for use in WBNP, Slave River Lowlands, commercial herds or other parks? Would salvaged bison be acceptable (for domestic and/or wild breeding stock) by Alberta and Northwest Territories authorities? How would preservation of hybrid bison affect the Wood Bison Recovery Program?

The feasibility of successfully isolating and maintaining a captive disease-free hybrid bison herd in the WBNP area is extremely remote.

There are several reasons for probable failure to achieve the objective of a captive disease free hybrid herd. The prevalence of bovine brucellosis and tuberculosis is approximately 37% in these bison. The tests available for the diagnosis of brucellosis and tuberculosis in the living animal are imperfect. This is compounded by the fact that latency can occur in both diseases, thereby, successfully thwarting the interpretation of the tests.

Strain 19 B. abortus vaccine which was very effective in increasing the resistance of bovine calves to B. abortus has been demonstrated to have a negligible effect on increasing resistance in bison calves.

One means that might be used to carry this out, which would certainly not be a guaranteed method, might be, firstly, to remove heifer calves from selected dams immediately after birth, keeping each animal in a separate enclosure with no contact between itself and any other calves or bison. Once a sufficient number of isolated calves were obtained, the original cow herd selected would be slaughtered completely. These slaughtered animals would be completely evaluated using postmortem techniques, bacteriology and serology for the presence of brucellosis and/or tuberculosis. The isolated calf groups would be monitored for brucellosis and tuberculosis on a regular basis using standard serological and intradermal skin testing techniques. Any reactor animals would be slaughtered and postmortem evaluations done, including bacteriology, serology and histopatholgy. The calves surviving to breeding age would be bred by artificial insemination using semen obtained from healthy wood bison bulls. Pregnancy would be closely monitored for the possibility of activation of latent brucellosis or tuberculosis. This whole process would have to continue for at least five years before the progeny might be considered free of brucellosis and tuberculosis. It is important to recognize that breakdowns could occur at any step along this pathway, which could then ruin the effort to eliminate the diseases.

The costs associated with this type of operation that would be assumed by Agriculture Canada would only be those involved in technical diagnostic support services.

The program, which does not fall under Agriculture Canada's mandate, would be conducted by a wildlife service under whose jurisdiction the animals fall.

If the purpose of salvaging healthy, hybrid bison was to repopulate WBNP and the Slave River Lowlands, then this would require that all free-ranging bison in the area be depopulated before the healthy hybrid bison could be released.

Agriculture Canada's opinion is that we do not foresee any need for this type of activity with regard to bison sales to commercial herds or for distribution to other Parks.

4.3.1.2 Is it possible to identify and salvage wood bison from WBNP, the Slave River Lowlands, and areas adjacent to the Park? How would this be carried out? Identify alternative means of carrying this out. What costs are associated with each of the above plans? Who would be involved? Is it possible to eliminate disease from these herds? How would this be carried out? What criteria would be used to determine that a salvaged herd is disease-free?

Agriculture Canada, because of the potential disease risk, is not in favour of this proposal. It is recognized that the proposal could add to the diversity of the wood bison subspecies gene pool however, the potential disease risks far outweigh any advantages.

The feasibility of being able to declare any salvaged wood bison free of bovine brucellosis and tuberculosis is low.

The same difficulties outlined in section 4.3.1.1 apply equally to this proposal. Briefly, these are the high level of both bovine brucellosis and tuberculosis in the Park bison, the potential for latency which these two diseases possess, and the imperfect sensitivity of the tests for brucellosis and tuberculosis.

If this procedure is considered to be essential, it is suggested that the following criteria be followed. Round up and isolate all bison which is determined to possess wood bison characteristics. These should be held in a double fenced enclosure with a usable corral and chute system, preferably in the Park (e.g. Sweetgrass). All bison to be tested for brucellosis and tuberculosis, all reactors to either test to be immediately slaughtered.

Build a second smaller double fenced enclosure with corrals and chute outside the Park. Move negative tested stock to small holding area. Subdivide the area with double fences, into at least three compounds. Allow the group to breed, then take all calves and isolate into a separate compound. Immediate isolation from the dam and hand raising would be ideal. Destroy the original generation. Allow the second generation to breed and harvest calves as before into a third isolation pen. Destroy second generation. All the third generation to breed. Test repeatedly for several years running. If the third generation remains test negative they could be considered for release. The appearance of test positive animals in the first, second or third generation would require the elimination of the entire isolated herd. The use of Strain-19 vaccine in bison calves is not recommended. All animals slaughtered must be carefully checked for lesions of tuberculosis and blood tested for brucellosis.

4.3.1.3 By what specific means could complete eradication of disease and/or hybrid bison be carried out? Assess the feasibility and effectiveness of each plan. What time frame would be required? Who would conduct a bison depopulation plan? What are the costs associated with each plan?

In Canada, as in other countries which have successfully eradicated bovine brucellosis or bovine tuberculosis, complete eradication requires the depopulation of infected herds along with the slaughter of any animals which have been in contact with animals from the infected herd. A herd is defined as "infected" even if only a single animal is confirmed to be infected by culture of the causative agent - Brucella abortus in the case of brucellosis or Mycobacterium bovis in the case of tuberculosis.

"Test and Slaughter" programs, where only the test positive animals are slaughtered and the test negative animals remain in the herd, were used to eradicate the disease from cattle and domestic bison herds until 1977. These programs helped to reduce the incidence of both diseases but an "Infected Herd Depopulation Policy" was required before complete eradication was achieved.

Canadian and American experience with both of these diseases is that if only test positive animals are removed from infected herds, apparent disappearance of the disease will be followed by reappearance (recrudesence) in 5 to 10 years. In one Saskatchewan herd from which tuberculosis was supposed to have been eliminated in the 1950's, infection reappeared nearly 30 years later in 1982.

Latent brucellosis infection was detected in a single cow in a Saskatchewan herd of 558 animals in May 1989. The entire herd was slaughtered and animals which had been sold out of the herd were traced into each of the other provinces and into several of the United States and were slaughtered.

Latent infection which is a feature of both of these diseases is well documented in the scientific literature (see References in Agriculture Canada's Proposed Course of Action).

It is for the above reasons that Agriculture Canada predicts that any method of disease elimination other than complete removal of all brucellosis and tuberculosis "exposed" bison in and around WBNP is doomed to fail. Only if it is crucial to the survival of the wood bison subspecies should heroic attempts be made to salvage genetic material from this diseased herd.

Discussions have been initiated at the Ministerial level in Agriculture Canada to explore ways of resourcing a "Proposed Course of Action". This proposal, discussed in the following chapter of this submission, is a detailed costed plan to remove all of the diseased exposed hybrid bison and to repopulate with wood bison from Elk Island National Park and the Mackenzie Bison Sanctuary. The depopulation phase employs a variety of proven techniques to roundup, capture and humanely slaughter the disease exposed animals. Repopulation would be accomplished by constructing a number of bison secure enclosures outside the Park to multiply annual contributions from Elk Island and the Mackenzie Sanctuary.

When the disease-free replacement animals reached sufficient numbers (see Annex II, page 77, Department of Environment Submission), the replacement herd could be moved into the WBNP into a large temporary enclosure(s) for a year. Multiplying facilities (enclosures) outside the Park could be turned over to bison ranching interests in the Slave River lowlands region. A proportion of the replacement wood bison would be made available as nucleus stock for the game ranches and for free roaming herds in the Slave River lowlands and selected sites outside the WBNP in northern Alberta.

The proposed project could be achieved in 8 to 10 years at an estimated cost of $20 million.

Management and administrative support for an operation of this magnitude would require a 10 to 15 person support staff. Agriculture Canada proposes that the Project Manager would be guided by an "Advisory Board" with representation from Canadian Parks Service, Canadian Wildlife Service, Agriculture Canada, Department of Northern and Indian Affairs, Health and Welfare Canada, NWT Renewable Resources, NWT Economic Development and Tourism, Alberta Agriculture, Alberta Fish and Wildlife, as well as representatives from local native peoples tribes and organizations. This Advisory Board would establish population goals.

4.3.1.4 How might bison meat and by-products be recovered, distributed and/or disposed of in an acceptable manner (include meat for human and animal consumption, hides, skulls, horns, and other by-products)? In what jurisdictions might such products be acceptable? What are the costs associated with the construction and operation of salvaging and processing facilities required to conduct an eradication program?

The salvage of meat and by-products from bison slaughtered in WBNP has a number of ramifications.

The public perception of meat from a "diseased herd" will likely result in resistance to buy the meat even though it has been processed in an abattoir operating under the Federal Meat Inspection Act.

The Canadian market for bison meat is in the development stages and if a large amount of bison meat was placed on the market it would cause a negative impact on the operation of bison ranchers.

The present bison population is considered to be aged given the very low level of recruitment of young animals being experienced by the herd. The majority of the meat that would be salvaged would come from aged animals. If this meat is sold in the general market, it would probably unfavourably influence people in future purchases of bison meat.

It is likely that the majority of bison meat salvaged, because of its low quality, would have to be used for mink and fox feed.

The prevalence of brucellosis and tuberculosis in the WBNP is around 37% for each disease and would likely result in a relatively high condemnation rate. All animals and carcasses would be inspected and tested at time of slaughter. Any having a positive brucellosis test or any lesions of tuberculosis would be rejected for use as human food.

Hides, capes, and horns could be processed by local native organizations for sale locally, nationally, or internationally depending on the market situation for these types of products.

It is impossible to estimate what revenue may be derived from the sale of bison meat and by-products. It would be unrealistic to assume that the revenue obtained would offset the cost of the slaughter and processing operations.

A detailed costing regarding the construction of slaughter facilities is included in the Agriculture Canada Proposed Course of Action in the following chapter.

4.3.1.5 By what means could wood bison be gradually reintroduced into the Park while disease elimination was underway? Consider the establishment of various sized contained nucleus herds located in a number of locations in the Park. From where could the bison be obtained? What costs would be associated with each depopulation option? How many wood bison would be required to eventually repopulate the Park? For how long would nucleus herds be contained? What population goals would be set for free-ranging herds? What time frame would be required? What criteria would be used to determine that the range is completely free of bison before a reintroduction of disease-free animals?

Please refer to 4.3.1.3. The details of timing, disease free criteria and costs are described in the Agriculture Canada Proposed Course of Action in the following chapter.

4.3.2.3 What is the potential for reinfection of bison with tuberculosis or brucellosis from other wildlife? Assess the risk posed by the presence of *Brucella suis* type 4 in nearby barren ground caribou.

The potential for reinfection of bison with brucellosis and/or tuberculosis by other wildlife is extremely rare, since there are no other primary reservoir species within the park region.

Brucella suis biovar 4 poses no risk to the bison population in the Wood Buffalo National Park region or elsewhere. Experimental studies have shown that this organism is adapted to caribou and reindeer, which are the primary host species. It is not maintained in cattle, sheep or pigs.

Field experience in the northern U.S.S.R., where cattle are moved into proximity with infected reindeer, has not indicated any problem with transmission of *B. suis* type 4 from reindeer to cattle.

The isolation of *B. suis* biovar 4 has not been documented in woodland caribou. These are the only species currently in contact with the bison of the Park region.

The Beverly barren ground caribou herd is known to be infected with *B. suis* biovar 4, but they do not have contact with bison at the present time. The last known migration of barren ground caribou though WBNP was in 1957.

Although barren ground caribou did at one time migrate through WBNP, there has been no evidence of any transmission of *B. suis* biovar 4 from the migrating caribou to the Park bison. Likewise, there has been no evidence of transmission of *B. abortus* or *Mycobacterium bovis* from the bison in WBNP to the Beverly caribou herd.

The wood bison in the Mackenzie Bison Sanctuary (MBS) have had opportunity for contact with woodland caribou yet there has been no evidence of *B. suis* biovar 4 in the bison in MBS.

4.3.2.4 What are the potential impacts of bison depopulation/repopulation activities on other wildlife? Consider disturbance from helicopters, airplanes, bison round ups and intensive harvesting of the bison.

The potential impact of bison depopulation and repopulation activities on other wildlife would be of two major types - direct and indirect.

The direct effects of depopulating bison would include such things as loss of a prey base for wolves. This question has been addressed elsewhere by the contractor to the FEARO panel.

There would be a loss of scavenging resource for other carnivors in the Park area for a short period of time.

There would be reduced competition for other herbivors, particularly moose, in the Park, and there would be a reduction of the possibility of transmission of brucellosis to moose. This would be beneficial to moose populations, since brucellosis is a serious, often fatal, disease in moose.

The indirect effects of bison depopulation, such as aerial surveillance and human activities, are not really completely understood. However, bison roundups for slaughter and vaccination in WBNP during the 1950's, '60's and '70's did not produce any noticeable effect on other wildlife that was ever suggested or implied in the Park literature and Park reports.

Major wildlife harvesting campaigns elsewhere in the world have not documented significant long term effects on non-target wildlife; for example, moose harvesting in Sweden or red deer harvesting in New Zealand.

Other forms of human disturbance that are currently taking place in WBNP, such as logging, hunting, trapping and active suppression of forest fires, have not been stopped; presumably because they produce no harmful, long term effects on wildlife populations in the Park.

Repopulation of WBNP with purebred, disease-free wood bison would likely reverse any of the negative trends seen in the depopulation phase. Carnivor populations would rebound as would scavenger populations.

In essence, the situation would be returned to its former assemblage of animal species.

4.3.5.3 What specific monitoring procedures and standards are required to ensure adequate disease-surveillance during and after repopulation with disease-free bison?

During the repopulation phase of WBNP, wood bison would be maintained within holding corrals. Monitoring would consist of doing full necropsies and technical workup on animals that were found dead within those corrals. Secondly, there would be periodic sampling of the animals in the corrals, either by culling or by periodic serum surveillance and skin testing, and thirdly, all wood bison within corrals would be tested for brucellosis and tuberculosis before they were ultimately released onto pasture in WBNP and the surrounding area.

After the repopulation, that is to say once wood bison have been released from corral systems into the clean range in and around WBNP, Agriculture Canada would suggest that similar surveillance be maintained.

We would suggest that necropsies be done on any bison found dead in the Park after the repopulation campaign is underway. Secondly, we would recommend that periodic sampling of bison be done either through a necropsy sample or by chemically immobilizing the animals and obtaining serum samples.

Agriculture Canada would provide technical diagnostic support if these recommendations were undertaken.

Once the reintroduced wood bison begin roaming outside of WBNP, we would recommend that blood and tissue samples be submitted from any bison that was shot by hunters outside of the Park area, as an auxillary surveillance system.

The animals that would ultimately be maintained within the Hanging Ice Bison Ranch and any other wood bison ranches in the area would fall under the jurisdiction of the Captive Wild Ungulate Program, which is maintained by Agriculture Canada. This would require periodic testing of animals. Animals that would be sent to any abbatoir facilities would also be carefully examined for the presence of brucellosis and/or tuberculosis, as well as other diseases.

AGRICULTURE CANADA'S

PROPOSED COURSE OF ACTION

NOVEMBER 17, 1989

C.1 INTRODUCTION

This chapter describes and rationalizes Agriculture Canada's "Proposed Course of Action". Agriculture Canada is absolute in it's contention that it is technically and logistically feasible and economically beneficial to eliminate this last known Canadian focus of bovine brucellosis and bovine tuberculosis. Alternative courses of action are discussed and arguments are presented to support the contention that a herd depopulation method is essential to achieving complete eradication of the two diseases.

The Bison Disease Task Force listed four options which it considered to be feasible - the status quo; a "Wood Bison Recovery" option involving salvage of wood bison genetic stock, elimination of the diseased herd and replacement with disease-free wood bison; a "Fencing" option; and a "Composite" option using combinations of buffer zones and strategically placed fences. The Environmental Assessment Panel in its information requests, outlined the following potential solutions to the risk of spread of the two diseases:

1. Current Status (Status Quo) with "Interim" protection measures.
2. Disease Containment by use of fencing, buffer zones or combinations of these methods.
3. Disease elimination by salvaging non-infected animals from the infected herd OR by depopulating the infected herd and replacing it with brucellosis and tuberculosis-free wood bison from sources outside WBNP.

The reader is referred to Agriculture Canada's responses to the Panel's information requests for a description of the actions that would be taken to prevent transmission or to deal with disease outbreaks that might occur. Interim measures of surveillance or containment by fencing and/or buffer zones would help to reduce the risk of spread of disease but as long as the diseased hybrid herd continues to exist, the risk of spread to cattle, other bison and people would remain. Fences and buffer zones are not very effective. The potential for this risk to suddenly increase to at least double its current threat is associated with potential spread into the Mackenzie Bison Sanctuary herd. This risk is now real and immediate. If this were to occur, the feasibility of disease eradication would be diminished significantly and the costs would be prohibitive.

At $2.6 million per year, the ongoing cost of implementation of the interim measures is equal to or greater than the cost of Agriculture Canada's "Proposed Course of Action". The drastic negative impact on Canada's agricultural economy (L. Quantz, page 288, Compendium of Government Submissions and Technical Specialist Reports) that would result from a serious outbreak of either of these two diseases renders the use of interim protection measures unacceptable. Expenditures to eradicate the diseases would be justifiable by a very positive benefit/cost ratio.

The Agriculture Canada information responses also indicate that Canadian and International experience has determined that neither brucellosis nor tuberculosis can be eradicated from infected herds by removing only animals that react positively to tests. Latently infected animals will be missed by the tests and will reintroduce infection throughout the herds at a later date. Canadian experience based on data from 1,000 herds in the past 15 years supports this. These two diseases can only be eradicated by depopulating the infected herd even when, as a result of testing, only one animal is found to be infected.

Agriculture Canada's Proposed Course of Action has raised some environmental and socio-economic concerns. These are addressed in section C.3.

Although a specific, fully costed detailed plan is presented, it is flexible in several respects. A variety of methods can be used to roundup the diseased animals; two types of slaughter facilities allow flexibility in processing; propagation of the replacement herd can be done in the Park or outside the Park; large enclosures or small enclosures can be used depending on whether or not supplemental feeding occurs. The plan is open to discussion of all aspects except the absolute need to remove all disease-exposed bison.

The proposal offers substantial long term benefits. Threats to public health will be removed. In addition to negating the potential risk of serious outbreaks of disease and the consequent economic hardships on Canadian agriculture, the proposal will re-establish large numbers of prolific, healthy wood bison across the north. This will be of great benefit not only to northern residents, but to all Canadians in addition to the conservation value of assisting with the recovery of the wood bison subspecies.

ACKNOWLEDGEMENTS

Agriculture Canada appreciates the assistance of Alberta Agriculture, Alberta Fish and Wildlife Division, Northwest Territories Renewable Resources and the Canadian Wildlife Service in developing this Proposed Course of Action.

C.2 MANAGEMENT PLAN

C.2.1 PLAN HI-LITES

The proposed course of action involves two components; the eradication of the bovine brucellosis and tuberculosis presently found in the disease-exposed bison in and around Wood Buffalo National Park, and a repopulation of these areas with healthy wood bison.

A number of corrals and handling facilities are needed to complete this task, including construction of two large corrals (one square kilometer each) and enclosures at Sweetgrass and Hay Camp in Wood Buffalo National Park in previously disturbed areas. The corrals would be used for capture and holding disease-exposed bison from the Park until shipment to an abattoir facility in Fort Smith. When the area is depopulated, these facilities could be used (after being empty for one year) to maintain and breed disease-free wood bison for eventual release into the Park as part of the replacement plan.

Also as part of the replacement plan, two large (100 square kilometers) double-fenced enclosures could be constructed in the Park to house and maintain breeding stocks of wood bison without supplemental feeding and for release to the wild to repopulate the Park. However, if this is not deemed feasible, other areas outside the Park could be selected for breeding compounds for wood bison - and likely at half the cost - without the need for double fencing (refer to C.3.8.).

Construction of a modestly sized, double-fenced display paddock for disease-free wood bison in the Park could be considered if that is deemed desirable.

In addition, two corrals (one square kilometer each, with ten square kilometer double-fenced enclosures) should be constructed at Hanging Ice Bison Ranch and Hook Lake, in the Slave River Lowlands, to maintain disease-free wood bison initially transferred from Elk Island National Park and the Mackenzie Bison Sanctuary. The amount of care and supplementary feeding required would be reduced in enclosures of this size. The second breeding herd of wood bison in the Slave River Lowlands is required for several reasons. Another herd of greater than 200 head would assist with removal of wood bison from wood bison from the endangered species list. Also, it could be used to restock the Slave River Lowlands with a disease-free wild population.

Construction of a large corral (one square kilometer) in the Mackenzie Bison Sanctuary is required to capture and test wood bison destined for shipment to the Hanging Ice Bison Ranch as breeding stock.

Construction of an abattoir and storage facilities at Fort Smith is required for the processing of live-captured, disease-exposed bison from the Park and surrounding area.

Construction of a winter road from Sweetgrass to Fort Smith (24 km) is required to transport captured bison to the abattoir. In addition, access roads to the Slave River Lowlands (Hook Lake and Hanging Ice) are required to initially stock the compounds, and so that surplus animals can be removed.

Corral and enclosure facilities at Hanging Ice, Hook Lake and the abattoir at Fort Smith are to be made available to other interest groups when sufficient numbers of disease-free wood bison are released to the wild in Wood Buffalo National Park and the Slave River Lowlands.

Compensation for disruption of hunting would include provision of 100 bison carcasses per year to people who lost their hunting opportunities because of the disease eradication and replacement plan.

C.2.2 DISEASE ERADICATION

The removal of 4,000 - 5,000 disease-exposed bison from Wood Buffalo National Park and adjacent areas could be accomplished in several ways. (Refer to C.4). A combination of methods may be more appropriate. The live capture option would require construction of facilities such as capture corrals, portable corrals, a permanent abattoir in the Fort Smith area, and a portable abattoir.

Agriculture Canada proposes construction of two corrals (approximately one square kilometer each) for the capture and holding of disease-exposed bison. To minimize environmental damage, two previously disturbed areas within WBNP, Sweetgrass and Hay Camp, have been suggested as corral sites. Furthermore, the Peace-Athabasca Delta area contains the largest concentration of disease-exposed bison within the Park. These corrals will be used to hold disease-exposed bison until transport to the permanent abattoir is possible. This will occur as soon as possible, to minimize the need for supplemental feeding of the captured bison.

Baiting bison with hay has been used successfully in winter months in Elk Island National Park and northern Alberta. This method should be attempted to capture disease-exposed bison in the two Park holding facilities at Sweetgrass and Hay Camp. The environmental concerns regarding the use of baiting with hay are addressed in section C.4. Baiting may not be effective because of animal distribution patterns and availability of native forage. Therefore, consideration should be given to using the most recent observations of bison migration patterns, the use of wing fences attached to the corrals, snow-plowed trails, and controlled hazing using air and ground techniques. It has also been suggested that darting a group of dominant cows and the addition of radio collars in year zero would assist determination of migration patterns and location of major groups of Park bison in the delta.

Following is a chart of the numbers of bison that could be expected to be taken out of the Peace-Athabasca delta each year, and the suggested removal method.

	Trapped Live & Moved to Ft. Smith Abattoir	Processed Through a Portable Abattoir	Supervised Shooting	Total
Year 3	800-1200	400-500	300-400	1500-2100
Year 4	600-1000	300-400	200-300	1100-1700
Year 5	400-800	200-250	100-150	700-1200

For smaller herds of bison which cannot be lured into the large capture facilities in Sweetgrass or Hay Camp, portable corral systems may be employed. These would be transported to the general areas where small groups are sighted, and using previously described baiting techniques, bison would be enticed into the corral. They would be held for a minimum period of time pending transport to the permanent abattoir.

As part of the live capture option, it will be necessary to construct a permanent abattoir and cold storage facility for processing the captured bison. The abattoir will be designed to meet Agriculture Canada's standards to accommodate federal meat inspection, processing and packaging. Edible products from this facility would be salable in Canada as well as on international markets. The abattoir will be small, with a kill floor approximately 30' by 40' using a hand push rail system. It will have a cooler capacity of 50 carcasses and a freezer capacity of 10 carcasses. Should the need arise, the abattoir could be modified to accommodate the processing of other species (including domestic species) in addition to bison. Once removal of the disease-exposed bison is completed, the abattoir facility could be made available to other interest groups.

A portable abattoir would be useful in the disease eradication process when smaller groups of bison are encountered, especially for those bison that evade capture and in those areas where transportation problems exist. Meat produced in such a facility, because of regulatory encumberances would not be exportable commercially but being fully inspected it would be available for human consumption and usable in Alberta and the Northwest Territories.

Small groups of bison and individual animals located in remote areas will probably have to be removed by supervised shooting by ground crews. In addition, any bison not previously removed by other means will be dealt with in the same manner.

C.2.3 REPLACEMENT WITH WOOD BISON

The proposal for replacement of disease-exposed bison with disease-free wood bison has three objectives. First, it is necessary to ensure that Wood Buffalo National Park maintains a viable population of disease-free wood bison. Second, it is desirable to establish another herd of disease-free wood bison to assist with the removal of wood bison from the endangered species list. And third, it is desirable to incorporate the Hanging Ice Bison Ranch as an integral part of the replacement option to provide breeding stock for restocking of the Slave River Lowlands with disease-free wood bison. This would establish another free-roaming herd that would create more opportunities for native people to hunt in their traditional way.

The replacement of wood bison in Wood Buffalo National Park will require the use of holding facilities and large fenced enclosures for the rearing and maintenance of stock for future release and establishment of wild herds. Although it would be desirable to construct enclosures in the Park to facilitate release and re-establishment of wood bison, there is no reason why rearing facilities cannot be located outside of the Park to avoid environmental impacts in the Park. Agriculture Canada is prepared to construct the required facilities wherever deemed suitable in terms of replacement and recovery of wood bison (refer to C.4.).

Agriculture Canada proposes to construct two large 100 square km double-fenced compounds in the Park around or adjacent to corral facilities, as proposed in section C.2.2, for the Sweetgrass and Hay Camp areas. These compounds could also be used to maintain disease-exposed bison until transfer to the abattoir in Fort Smith is possible. After being vacant for a season (one summer at least), they could be used to hold wood bison replacement stock. The double fencing would ensure that no strays (disease-exposed bison) could contact the wood bison and spread disease. Removal of the Hay Camp and Sweetgrass facilities, once bison are released into the Park, can occur, if deemed necessary. The Park enclosures are considered to be large enough to sustain a large herd of bison without supplementary feeding. Assuming a carrying capacity of 7 bison per square km, these two enclosures should support about 1400 wood bison on a year round basis without supplementary feeding. Provision of supplementary feed would permit an increase to the stocking rate. Native hay from nearby meadows should be prepared and made available in the case of an emergency.

In addition, two breeding compounds (corrals and enclosures) are proposed for the Slave River Lowlands. One is a site already proposed for the Hanging Ice Bison Ranch; the other is at Hook Lake, an already disturbed area.

Each of these facilities would involve corrals (one km square) and double-fenced compounds encompassing 10 square km. Each of these compounds should be able to support about 70 wood bison without supplementary feeding, based on a carrying capacity of 7 bison per square km. Supplementary feeding will be used as required or compounds will be expanded in size. These breeding facilities can be put into operation as soon as the Slave River Lowlands have been depopulated of the approximately 400 disease-exposed bison. Source stock from the Mackenzie Bison Sanctuary (100/year) and Elk Island National Park (40 - 50/year) will be individually or tagged, brucellosis and tuberculosis tested, and anthrax vaccinated before transfer to these breeding compounds (refer to C.4.). A key component of the replacement plan is the use of these two compounds on the Slave River Lowlands as breeding and holding facilities for disease-free wood bison stock. Wood bison produced in these compounds could be transferred to Park enclosures as soon as it is feasible and safe to do so.

In consideration of a perceived need to display bison in the Park during the replacement phase, a rapid increase of the replacement herd is deemed desirable. Stock from the Hanging Ice Bison Ranch and the Hook Lake breeding facilities would to be used in addition to continuous annual supplements from Elk Island National Park and the Mackenzie Bison Sanctuary.

To assist with the recovery of wood bison and the eventual delisting by the Committee on the Status of Endangered Wildlife in Canada, it is important to establish large, free-roaming herds of wood bison. An increase in the number and size of individual breeding herds of wood bison will be possible with good management and lack of disease problems. There appears to be a potential to increase total numbers of wood bison in northern ranges in and around Wood Buffalo National Park to approximately 15,000 animals, after diseased hybrid bison are removed and replaced. Population sites of this magnitude in the Slave River Lowlands and northern Alberta could support harvesting at the rate of about 10%, or approximately 500 bison per year.

C.2.4 TIMETABLE FOR REPLACEMENT OPTION

YEAR 0

Radio collar dominant cows to study movement patterns.

Begin test baiting of bison with hay.

Complete phenotypic assessment of existing bison in the Park and Slave River Lowlands, if required.

YEAR 1

1. Start building corral at Hook Lake (1 square km.) Start building corral at Hanging Ice Bison Ranch (1 square km), if not already underway. Also, start building a corral at Sweetgrass, Hay Camp, and the Mackenzie Bison Sanctuary,(one square km each).
2. Test feasibility of baiting bison with hay into a corral system (winter only).
3. Start building slaughter, storage and rendering facilities at Fort Smith. (See Appendix II).
4. Start building double-fenced enclosures (100 square km each) at Sweetgrass, Hay Camp and (10 square km each) at Hanging Ice Bison Ranch and Hook Lake.
5. Build 24 km of road needed between Sweetgrass and Fort Smith so captured bison can be trucked to Fort Smith for slaughter. Also, additional roads may be built to Hanging Ice and Hook Lake sites.
6. Start field slaughter of bison in remote areas during the winter; for example, the areas in the northwest and southwest corners of Wood Buffalo National Park, as well as adjacent areas in Alberta in areas of highest risk.

YEAR 2

1. Complete abattoir and storage facilities at Fort Smith.
2. Start transfer of disease-free wood bison to the Hanging Ice Bison Ranch.
3. Start roundup activities by hay baiting bison into Sweetgrass and Hay Camp corrals.
4. Establish hay storage depot in Fort Smith (on abatttoir property).

YEARS 3 - 8

1. Add a total of 130 - 150 disease-free wood bison to Hanging Ice and Hook Lake holding facilities each year. In addition, direct stocking of Park enclosures can occur. An agreement among the Government of the Northwest Territories, the Denendeh Conservation Board and local communities can be reached to supply 90 - 100 wood bison per year from the Mackenzie Bison Sanctuary. The Canadian Wildlife Service and Elk Island National Park have agreed to provide 40 - 50 wood bison per year from the herd at Elk Island National Park for the recovery of wood bison.

2. Begin slaughter of disease-exposed bison from the sweetgrass and Hay Camp areas. Transfer any captured bison to the abattoir in Fort Smith for disposal.

3. Continue field slaughter in remote areas, including Slave River Lowlands.

4. All removal to be done in as short a time frame as possible.

NOTE: Sweetgrass and Hay Camp corrals and enclosures need one summer "empty" before reintroduction of disease-free wood bison from Hanging Ice or Hook Lake breeding corrals. Disease control measures must be secure and without risk.

C.2.5 COSTS - YEARLY BREAKDOWN

Year	Description of Costs	Total Cost of Project	Yearly Cost	Total Cost Each Year
1	Start & complete 5 corrals	1,000,000	1,000,000	
1	Start 2 double-fenced enclos. 100 sq km ea	1,600,000	800,000	
1	Start 2 double-fenced enclos. 20 sq km ea	560,000	280,000	
1	Start Road Construction to Sweetgrass, H.I. & H.L.	1,500,000	750,000	
1	Road Maintenance/snow ploughing	2,000,000	200,000	
1	Start one Abattoir/Freezer	1,750,000	1,000,000	
1	Start & complete 1 Portable Abattoir	500,000	500,000	
1	Rendering of Condemned Material	1,640,000		
1	Start & Complete 1 corral & hay shed at Abattoir	50,000	50,000	
1	Start bison transport EINP to HI 50 head, 3 trips	94,500	9,450	
1	Start bison transport MBS to HI 100 head, 5 trips	52,500	5,250	
1	Start surveillance	1,900,000	190,000	
1	Start furnish. carcasses to Natives	1,000,000	100,000	
1	Start Special Assistance Fund Hunting & Carcass Removal	1,000,000	100,000	4,984,700
2	Complete 2 double-fenced enclos. 100 sq km ea		800,000	
2	Complete 2 double-fenced enclos. 10 sq km ea		280,000	
2	Complete road construction to Sweetgrass, HI & HL		750,000	
2	Road maintenance/snow ploughing		200,000	
2	Complete 1 Abattoir/Freezer		750,000	
2	Rendering		546,667	
2	Bison transport EINP to HI		9,450	
2	Bison transp. MBS to HI		5,250	
2	Surveillance		190,000	
2	Furnish Carcasses to Natives		100,000	
2	Special Assist. Fund, Hunting & Carcass Removal		100,000	
2	Start transfer Park Bison 1,500 hd to Ft. Smith	853,000	286,550	
2	Start Tranfer Park Bison-barge costs	1,000,000	333,334	
2	Start Abattoir operating costs	2,750,000	550,000	4,901,251

Year	Description of Costs	Total Cost of Project	Yearly Cost	Total Cost Each Year
3	Road Maintenance/snow ploughing		200,000	
3	Bison Transport EINP to HI		9,450	
3	Bison Transport MBS to HI		5,250	
3	Surveillance		190,000	
3	Furnish Carcass to Natives		100,000	
3	Hunting/Carcass Removal		100,000	
3	Transfer Park Bison to Ft. Smith 1500 head		282,000	
3	Transfer Park Bison - barging costs		333,333	
3	Abattoir Operating Costs		275,000	
3	Rendering		546,666	2,041,699
4	Road Maintenance/snow ploughing		200,000	
4	Bison Transport EINP to HI		9,450	
4	Bison Transport MBS to HI		5,250	
4	Surveillance		190,000	
4	Furnish Carcasses to Natives		100,000	
4	Hunting/Carcass Removal		100,000	
4	Complete Transfer Park Bison to Ft. Smith - 1500 head		282,000	
4	Complete Transfer Park Bison barging costs		333,333	
4	Start Bison Transport (pure wood bison) HI to Sweetgrass-50 head		550	
4	Abattoir Operating Costs		275,000	
4	Rendering		546,666	2,042,249
5	Road Maintenance/snow ploughing		200,000	
5	Bison Transport EINP - HI		9,450	
5	Bison Transport MBS - HI		5,250	
5	Surveillance		190,000	
5	Furnish Carcasses to Natives		100,000	
5	Hunting/Carcass Removal		100,000	
5	Abattoir operations		275,000	
5	Bison Transport HI to Sweetgrass 60 head		550	880,250
6	Road Maintenance/snow ploughing		200,000	
6	Bison Transport EINP - HI		9,450	
6	Bison Transport MBS - HI		5,250	
6	Surveillance		190,000	
6	Furnish Carcasses to Natives		100,000	
6	Hunting/Carcass Removal		100,000	
6	Abattoir Operation		275,000	
6	Bison Transfer HI to Sweetgrass 70 head		600	880,300
7	Same as Year 6 (80 head)			880,300

Year	Description of Costs	Total Cost of Project	Yearly Cost	Total Cost Each Year
8	Road Maintenance/snow ploughing		200,000	
8	Bison Transport EINP - HI		9,450	
8	Bison Transport MBS - HI		5,250	
8	Surveillance		190,000	
8	Furnish Carcasses to Natives		100,000	
8	Hunting/Carcass Removal		100,000	
8	Abattoir operation		275,000	
8	Bison Transport HI to Sweetgrass 90 head		750	880,450
9	Same as Year 8 (100 head)			880,450
10	Road Maintenance /snow ploughing		200,000	
10	Bison Transport EINP - HI		9,450	
10	Bison Transport MBS - HI		5,250	
10	Surveillance		190,000	
10	Furnish Carcasses to Natives		100,000	
10	Hunting/Carcass Removal		100,000	
10	Abattoir operation		275,000	
10	Bison Transport HI to Sweetgrass		750	
10	Removal of park facilities later	750,000	750,000	1,630,450
			TOTAL	$ 20,000,000

C.3 PREVENTION OF ENVIRONMENTAL AND SOCIAL PROBLEMS

C.3.1 Hunters of Bison are at Risk of Contracting Brucellosis and Tuberculosis

Neither brucellosis or tuberculosis bacteria are found in high numbers in muscle tissue (meat). Therefore, eating meat from the diseased hybrid bison poses no significant risk.

Hunters and butchers of the diseased bison are at risk unless protective clothing and rubber gloves are worn. If actual lesions (swollen joints, affected lungs, the uterus and fetus) are encountered, bacteria found in the exudates and fluids in large numbers can enter the hunter's body through cuts in the skin, through the membranes of the eyes, nose and mouth or they can be inadvertantly swallowed.

It is logical for hunters of the diseased bison to have doubts about this risk because the symtoms of brucellosis are similar to those of other common illnesses. A hunter might assume he had "the flu" because his symptoms were fluctuating fever, muscle aches, joint pain, headaches, loss of appetite, etc., when actually he was suffering from brucellosis. Unless he visited his doctor and his doctor suspected and performed specific tests for brucellosis, his case would go undiagnosed.

It is well documented in the scientific literature that both diseases readily spread to people who work with infected animals or their tissues (see attached "Synopsis and Literature: Zoonotic Aspects of Brucella abortus and Mycobacterium bovis with Special Consideration of the Reservoir of Brucellosis and Tuberculosis in Bison in and Around Wood Buffalo National Park; Stacy V. Tessaro, 1989).

C.3.2 Protection of Abattoir Workers from the Diseases

Hunters and abattoir workers working with the diseased bison will be at risk of becoming infected with brucellosis or tuberculosis unless protective measures are implemented. These workers will be enrolled in Agriculture Canada's Training and Orientation on Safety Measures to be taken in this activity so that all will be aware of and be able to avoid unsafe procedures or activities. The workers will be closely supervised by veterinary meat inspectors and will be required to wear protective clothing and masks.

All workers will be closely monitored by Public Health Authorities. They will be tested for brucellosis and tuberculosis before being employed and the tests will be repeated periodically throughout the employment period. Any sign of illness will lead to prompt medical attention.

C.3.3 Compensation People will Receive for the Loss of this Important Cultural, Economic and Natural Resource.

This subject is well documented in Agriculture Canada's "Proposed Course of Action".

A number of considerations are made in that proposal, some of which are of direct and others of indirect benefit.

Some of these are:

- the meat from slaughtered bison, that is fit for human consumption, can be made available to local communities,
- 100 bison carcasses per year will be made available to people who lose their hunting opportunities because of depopulation,
- short term employment and long term employment will be created.

Short term employment examples:

- related to depopulation and repopulation efforts such as the building of enclosures, roads, collecting and handling of bison,
- contracts to cut and put up hay
- surveillance during the depopulation phase.

Long term employment opportunity examples:

- development of bison ranching in the area
- abattoir construction and longer term operation

C.3.4 The Economic Value of Bison Meat Obtained by Hunters and the Loss it would Represent to People

From the estimates made by Parks Canada (4.3.3.1) from 60 to 140 bison are harvested outside the Park's boundaries per year.

Agriculture Canada's Proposed Course of Action" makes provision for 100 bison carcasses per year to be made available to people who lose their hunting opportunities because of depopulation. The proposal also recommends that meat compensation must continue until enough free-roaming bison are available outside the Park or until the population in the Park is equal to or greater than that when the depopulation was instituted. The source of this bison meat is envisioned as coming from surplus stock from the Hanging Ice Bison Ranch or from commercial (plains) bison meat.

C.3.5 The Ethics and Morality of Killing the Large Diseased Bison Herd

Native people and others have questioned the need to slaughter such a large number of animals. Agriculture Canada believes that the killing of even a single animal for any reason should be thoroughly examined to ensure that the need to take life is legitimate.

In the case of these diseased hybrid bison, the morality of not dealing with the suffering caused by the diseases must also be questioned. Is it ethically and morally proper to allow animals crippled by brucellosis arthritis or animals emaciated and overcome by generalized tuberculosis to die a slow and lingering death?

Knowing that there is no practical way to determine an individual animal's freedom from the diseases, Agriculture Canada recommends the humane slaughter of this infected herd. This would make way for the reintroduction of a large, prolific, free-roaming herd of healthy wood bison. The social benefits of re-establishing "large" healthy herds of wood bison over their traditional range makes the somewhat controversial means of dealing with this problem more acceptable.

C.3.6 The Social and Cultural Value of Bison to Native People

Native people have spoken of the social and cultural value of bison. This is understandable. The wood bison and the native people were present in the area hundreds of years before Europeans. Aboriginal peoples' cultures around the world developed in concert with their animal neighbors.

Agriculture Canada with its Proposed Course of Action clearly recognizes the need to assure an ongoing presence of bison for the use and benefit of native people in all of the communities in the WBNP region. The result of implementation of the proposal, over the longer term, will lead to the establishment of free-roaming healthy wood bison in much larger numbers than the number of diseased hybrid animals which are now inhabiting the Slave River lowlands, the WBNP and some areas of Northern Alberta. In addition, facilities near Hanging Ice and Hook Lake used to multiply the replacement wood bison will be turned over to bison ranching interests following replacement of the WBNP herd. Native peoples have indicated an interest in bison ranching.

C.3.7 The Potential Impact of Bison Eradication on the Wolves and other Predators and Herbivores

Information related to this question has been summarized by Francois Messier, Department of Biology, University of Saskatchewan. This was prepared on behalf of the Federal Environmental Assessment Review Office and Panel.

The report entitled "Effects of Bison Population Changes on Wolf Dynamics in and around Wood Buffalo National Park" provides a number of conclusions from the information available.

Some general overall conclusions are reiterated by Francois Messier. With regard to the population status of the bison - "natural levels of wolf predation and the presence of brucelosis and tuberculosis were associated with a sustained decline of the bison population." He also concludes "the current situation in the Park does not ensure the long-term survival of the bison population".

He further states "a reduction of the bison prey base will force wolves to decline, particularly the wolf packs inhabiting primary bison ranges". He goes on to say that the wolf population will not reach zero, and will rebound again when healthy bison repopulate the Park.

From his review, Messier does not conclude that furbearing species will be affected.

Concerning the relationship of wolves to moose densities in forested areas (secondary bison ranges), he concludes that "wolves seem rare in moose ranges presumably because of the relatively low density of moose".

Concerning the prediction that the wolf population will increase when repopulation with bison in the Park occurs, Messier states that the impact of wolf predation on moose after repopulation is unknown.

Agriculture Canada agrees with his advice that a tri-annual moose survey should be conducted during depopulation - repopulation programs to assess the impact of displaced wolf predators on moose. He stressed that this is of utmost concern because of the reliance of Indian people on moose for their livelihood.

C.3.8 ALTERNATIVES TO LARGE HOLDING AREAS IN AGRICULTURE CANADA'S PROPOSED COURSE OF ACTION.

Agriculture Canada's proposed course of action includes the construction of two enclosures of 100 square km each. These are to be double-fenced and within the Park at Sweetgrass and at Hay Camp respectively.

The double-fenced enclosures within the Park bounadry are given consideration in the proposal because:

(i) they would be useful in corralling the diseased Park bison.

(ii) the enclosures, after being vacant for a year (to allow any contamination to destruct) would be used to hold disease-free wood bison.

Using the enclosures to hold disease-free wood bison would allow for the propagation of the bison within the Park and would encourage habitation to the Park.

The use of the enclosures in this fashion was also included to ensure that Wood Buffalo National Park would not be without bison during the 8 to 10 year program.

However this could also be achieved by using a smaller facility to allow visitors and tourists to observe wood bison in their natural habitat.

The large size of the facility would allow a significant number of bison to be held without the need to supplement their feed supply. Such supplementation is discussed further in C.3.8. It is estimated that the carrying capacity of the area could accommodate 5 to 10 head per square km (H. Reynolds pers. communication). An average of 7 head per square km is used to estimate the holding capacities of these enclosures. The enclosures thus should sustain 700 head each or a total of 1400 head.

The disadvantages of two 100 square km double-fenced enclosures must also be addressed.

Environmental concerns are:

- Physical damage and disturbance caused by the construction and maintenance of double-fences 40 km long in each of the two areas. The wheeled traffic could cause permanent trails around the perimeter which would encourage wildlife traffic. The result could be compaction and erosion along these trails.
- Some compaction to the surface in areas within the enclosures by the animals.

- introduction of weeds and grass seeds exotic to the area if supplemental feeding becomes necessary. There are ways to mitigate this potential problem (see C.3.9).

It is recognized that the proposed enclosures would alter the area and for this reason the sites at Sweetgrass and Hay Camp were suggested as they have been previously disturbed.

An alternative to double-fenced enclosures in the Park is considered here. Such an alternative would be to delay introduction of wood bison into the Park until after the surveillance period assured that no diseased hybrids remain. Wood bison propagated elsewhere could then be introduced into single-fenced enclosures and held until habituated to the area and then released.

These enclosures would be of sufficient size to sustain the animals without supplemental feeding, but if necessary hay harvested from within the Park could be used (see C.3.9). Their location in the previously disturbed areas of Sweetgrass and Hay Camp would be essential.

These facilities could be much smaller since each group would be released when ready. Several such smaller enclosures could be used when new wood bison additions were available. They would be cheaper to construct than double-fenced and could also be removed with less effort.

By eliminating large (100 square km) double-fenced enclosures within the Park, significant propagation potential during depopulation/repopulation would not be carried out there. Therefore the plan to multiply (breed) bison outside the Park would have to be expanded.

Facilities used to multiply replacement bison outside of the Park in the Slave River lowlands could be turned over to bison ranching interests (Hanging Ice, Hook Lake).

If outside the area, a practical and successful method of propagation of wood bison could be done by contracting out to livestock enterprises in the south. It would be imperative that a modified Agriculture Canada Health Accredited Herd type of program be established to insure complete isolation from diseases of other livestock.

Such enterprises would have less serious environmental impacts, would rapidly multiply the wood bison and on completion, permit transfer of all animals back to their historic range. For these reasons serious consideration to this method should also be considered.

C.3.9 Preventing the introduction of Non Native Plant Species into the Park

Concerns have been raised that during the replacement phase, if disease-free wood bison are to be propagated and multiplied in the Park, that the use of hay could inadvertently introduce non native plant species.

A number of ways of addressing this concern are available. The Agriculture Canada proposal is sufficiently flexible to accomodate any of these alternatives.

1. Only locally harvested hay would be used in the Park.

2. If hay were to be brought into the Park from external sources, only "clean" alfalfa would be used (seeds in alfalfa hay will not germinate).

3. The use of hay in the Park could be avoided by using crushed grain or pelleted feeds. (The crushing and the heating processes destroy germination).

4. The replacement bison could be multiplied outside of the Park entirely (C.3.8). This would allow a more indiscriminant use of feed without disturbing the ecology within the Park.

C.4 Will the Plan Work? - Feasibility and Effectiveness.

C.4.1 Feasibility of Capturing all of the Disease-Exposed Bison

International experience demonstrates that complete elimination of the diseased hybrid bison could be achieved by a combination of capture, field slaughter and supervised hunting. Three examples are:

1. Australia has nearly eradicated tuberculosis on its extensive cattle properties (often measuring 100 miles x 150 miles) using a process that is identical to the Agriculture Canada proposal. Enclosures are built and up to 20,000 feral ("wild") cattle are rounded up mostly by helicopter hazing and are shipped to market by truck and rail. The diseased herds are then replaced by animals free of tuberculosis and brucellosis.

2. The United States Department of Agriculture removed 12,000 tuberculosis infected feral cattle from the Hawaian Island of Molokai in 1985-87. The island is 45 miles x 3 miles and large areas are covered by jungle. The cattle were "rounded up" by horsemen and by helicopter hazing (M. Essey, U.S. Department of Agriculture).

3. Between 1982 and 1984, more than 7,000 tuberculosis infected feral water buffao were rounded up by helicopter hazing from an area of 380 km^2 of northern Australian monsoonal, jungle covered lowlands (Ridpath et al, Wildlife Society Bulleting 16:385-390, 1988).

Depopulation of a majority of the diseased bison will be achieved in 3 or 4 years. Intensive aerial surveillance over a subsequent 2 year period is expected to confirm that all bison have been removed. An additional 2 years of aerial surveillance would total 4 years with no sightings of diseased bison and provide a liberal margin of safety.

C.4.2 Proof of Prevalence of Brucellosis and Tuberculosis in the Hybrid Bison

During the Panel scoping sessions native peoples questioned claims by the Task Force that the prevalence of diseases in the hybrid bison approached 50%. This is understandable in as much as less than 10% of animals infected with brucellosis have visible lesions. At slaughter, they appear to be physically normal. Similarly, lesions of tuberculosis can be very small (less than 1 cm) and are easily overlooked.

During the 1950's and 1960's when the bison were being slaughtered for meat, veterinary inspectors found lesions of tuberculosis in 39% and blood testing indicated that 30% had brucellosis. In 1987, Dr. S.V. Tessaro performed tests on 56 bison killed by local hunters and found that 43% had brucellosis or tuberculosis or both diseases.

C.4.3 Effectiveness of Completely Eradicating Brucellosis and Tuberculosis by Removing all of the Disease-Exposed Hybrid Bison

Complete depopulation of 1028 infected cattle herds and 3 infected domestic bison herds between 1974 and 1989 followed by thorough cleaning of their premises and a vacant period of 30 days effectively eradicated both diseases. There has been no recurrence of infection on these premises following herd depopulation.

There is a concern that other wildlife in and around WBNP could act as reservoirs. In 1987, Dr. S. Tessaro reported that 698 rodents, 37 foxes, 13 wolves, 13 fishers, 12 black bear, 8 martens, 7 lynx, 5 moose, 4 mink, 4 woodland caribou, 2 coyotes and 2 wolverine were examined for brucellosis and for tuberculosis. No tuberculosis was found, but brucellosis was detected in 4 wolves, 1 fox and 1 moose.

During brucellosis eradication in the national cattle herd, brucellosis infected farm dogs were encountered on several occasions. There was never any transmission back to cattle. There would be even less chance of spread from free-roaming wolves or foxes to free-roaming bison.

Brucellosis usually causes death in moose. Consequently there is no risk of spread. Even if a moose survived with brucellosis, because they rarely mingle with bison, it would not be an effective transmitter of the disease.

There is no evidence that caribou, deer or other species in the Park are infected (refer to Agriculture Canada Response to Panel Information Requests, Question No. 4.3.2.3).

C.4.4 The Feasibility of the Combined Fence and Buffer Zone Option

This subject is reviewed at length in the article "Critique of Buffer Zone, Fencing, Composite, and Status Quo Options (Appendix I).

The Critique describes two attempts at utilizing the buffer zone option in bison. Both were unsatisfactory because of continuous movement of bison into the buffer zone.

The second part of the Critique discusses the inability of the Status Quo, Fencing and Composite options in preventing the contact of infected bison to non-infected animals in the long term.

It describes the negative aspects of adopting these options. The costs of maintaining such systems, including dollars as well as unusable areas.

The article summarizes the Buffer Zone, Fencing, Composite and Status Quo Options with 17 reasons why they would fail.

C.4.5 The Risk of Spread of Brucellosis and Tuberculoisis to Domestic Livestock

The reader is referred to The Compendium of Government Submisions and Technical Specialist Reports, section 5.0, page 285, "Quantitative Analysis of Risks to Livestock Producers" and "Transmission of Bovine Brucellosis and Tuberculosis from Bison to Cattle", S.V. Tessaro (Appendix II) for a scientific analysis of the level of risk.

The risk of transmission is real. It is well documented that brucellosis and tuberculosis can be transmitted from bison to cattle.

Transmission of brucellosis from captive bison to cattle initiated an outbreak of the disease in North Dakota (a brucellosis-free state) in 1983. The 1989 outbreak of brucellosis in cattle in Wyoming (a brucellosis-free state) was traced to infected, free-ranging bison and/or elk. The disease was also transmittted from bison to cattle that were held in the same pen during an experiment. Isolates of Brucella abortus from bison in Wood Buffalo National Park have all been varieties known to cause disease in cattle, and have been shown to be infective for cattle.

The causative agent of tuberculosis in bison in Wood Buffalo National Park is Mycobacterium bovis, the agent that causes tuberculosis in cattle. A large outbreak of bovine tuberculosis occurred in farmed bison herds in the U.S.A. in 1984 and 1985. Movement of infected bison resulted in the disease being spread through 21 herds in 10 states. Eradication of the disease required the slaughter of 1,086 bison, 878 cattle and 42 swine and goats.

Agriculture Canada believes that is is better to prevent spread of the diseases to livestock or other bison than it is to wait until it happens before taking action.

C.4.6 Species of Animals which may have to be Eliminated in the Future to Protect Cattle and Disease-free Bison

The brucellosis infected bison herd in and around WBNP is the last known focus of bovine brucellosis in Canada. Testing programs are in place to confirm the free status in game ranched animals across the country. Brucellosis testing in abattoirs will continue until at least 1992 to ensure that any latently infected cattle are detected. Therefore, although the host range for bovine brucellosis is very wide, there will be no source of infection.

Furthermore, even if a source of infection was present, only a few of the susceptible species are effective transmitters of bovine brucellosis - cattle, sheep, goats, bison, and captive or semi-confined elk. Thus it will not be necessary to eliminate any other animal populations in the future.

C.4.7 A "Realistic" Time Table for the Agriculture Canada Proposed Course of Action

In section C.4.1 the feasibility of removing all of the diseased bison was confirmed. The time allotted for this activity (C.2.4 and C.2.5) is 7 to 8 years. The time required for depopulation exercises in the international examples of comparable programs described in C.4.1 varied from 1 year to approximately 2.5 years. Based on these experiences the time frame proposed for the depopulation phase in this project is assumed to be realistic and probably has a built in margin of safety.

Replacement animals will be multiplied as the diseased herd is removed. This means that within an 8 to 10 year period there will be approximately 4,000 healthy wood bison to put back into the Park. In addition, there will be sufficient numbers to establish free-roaming herds in Northern Alberta and the Slave River lowlands. Native peoples in Fort Smith and Fort Resolution will be able to establish bison ranching enterprizes at Hanging Ice and Hook Lake.

C.5 ADVANTAGES AND DISADVANTAGES

C.5.1 ADVANTAGES:

1. From an agricultural interest, the replacement option will provide the only satisfactory resolution to the tuberculosis and brucellosis problem by eliminating the present threat to domestic stock.

2. Wood Bison Recovery

   a. Implementation of the disease eradication and replacement option will eliminate any direct danger of the transmission of bovine diseases (tuberculosis and brucellosis) to the Mackenzie Bison Santuary population, the largest free-ranging herd of wood bison in the world.

   b. The Mackenzie Bison Sanctuary is home for the world's largest herd of disease-free wood bison which is considered to be a national heritage resource.

   c. Establishment of two wood bison breeding herds in the Slave River Lowlands within the original range of the wood bison will assist their recovery. The establishment of four separately managed breeding herds of wood bison of more than 200 head in each will permit removal of wood bison from the endangered species list.

      i) Native people have expressed a concern that hunting rights might be restricted for wood bison. In the Northwest Territories, wildlife species declared endangered pursuant to section 1(3) of the NWT Act are: (1) Barren ground caribou (including Peary caribou), (2) muskox, (3) polar bears, and (4) wood bison. However, under a quota system some regulated hunting is permissible some species declared endangered as exemplified by barren-ground caribou, polar bears and wood bison. Therefore, regulated hunting of wood bison is the NWT is not anticipated to be a problem.

      ii) Present regulations in Alberta do not allow commercial sale of wildlife meat or their products. In addition, wood bison are listed as an endangered species in the Alberta Wildlife Act, therefore prohibiting private ownership.

   d. Implementation of this proposal will repopulate Wood Buffalo National Park with disease-free wood bison by:

      i) constructing holding facilities for wood bison in the Park areas and/or in areas adjacent to Wood Buffalo National Park.

ii) establishing a wild disease-free wood bison herd on federal lands that would be protected under the National Parks Act for long term conservation.

iii) using as short a time frame as is feasible between the disease eradication phase and the replacement phase to help alleviate concerns regarding potential negative impacts on tourism.

3. Establishment of a viable wood bison ranch in the Slave River Lowlands is desired by Native people.

   a. The wood bison ranch provides an excellent opportunity for Native people to cooperatively participate in the disease eradication program for wood bison replacement.

   b. The Hanging Ice Bison Ranch provides a desirable alternative to the declining diseased bison population in the Hook Lake area of the Slave River Lowlands.

   c. At the termination of the replacement project for Wood Buffalo National Park, the Ranch facilities on the Slave River Lowlands and abattoir in Fort Smith could be turned over to interested user groups.

4. Establishment of a free-roaming population of disease-free wood bison would strengthen the "World Heritage Site" designation for Wood Buffalo National Park and would support the World Conservation Strategy by:

   a. reintroducing a major population of wood bison within the historical range,

   b. fostering conservation of a national resource and assisting with recovery of threatened wildlife, and by

   c. fulfilling a Canadian obligation to correct past mistakes regarding conservation of wood bison.

5. Implementation of the replacement option will increase employment opportunities for local communities and for Native people in the Wood Buffalo National Park region.

   a. Initially, construction crews will be required to build corrals and fences at Sweetgrass, Hay Camp, Hanging Ice Bison Ranch, and Hook Lake, and to construct the abattoir at Fort Smith.

   b. Short-term employment will be created once the abattoir and storage facility is built at Fort Smith, during the construction of the 24 km road to connect Sweetgrass with the road to Fort Smith, and after the road is built.

c. Short-term employment will be created to bait bison into the Sweetgrass and Hay Camp enclosures to handle animals once they are rounded up and to load bison for shipment to the abattoir in Fort Smith.

d. There will be contract employment opportunities for preparing hay for Sweetgrass, Hay Camp, and the Hanging Ice Bison Ranch sites.

e. Longer term employment will be required for surveillance and portable abattoir crews during the disease eradication phase until the disease-exposed bison are removed.

f. Site managers will be needed over a longer term at Hanging Ice Bison Ranch, Hook Lake, and Sweetgrass.

g. Seasonal work will be available when the abattoir in Fort Smith is operational.

h. It is estimated that during years one (1) and two (2) seventy (70) seasonal jobs will be available each year for Native people. During years three (3) through eight (8) there will be thirty (30) seasonal jobs available.

6. Implementation of the replacement option will increase business opportunities and thereby enhance local economies in the region by:

   a. providing guiding and outfitting opportunities, and

   b. enhancing the processing and sale of bison products, such as meat, hides, capes, and other non-consumptive parts through commercial outlets.

7. Disease eradication and recovery of wood bison in Wood Buffalo National Park and adjacent areas would allow Alberta to proceed with the reintroduction of wood bison into northwestern Alberta.

8. Returning Wood Buffalo National Park to its original purpose would be a significant national conservation effort. It would reestablish wood bison in natural habitat within its historic range with the potential to become the world's largest naturally regulating disease-free herd of wood bison. Implementation of the disease eradication and replacement plan would provide a satisfactory resolution to the disease problem. In addition, the heritage resource of wood bison would be maintained in a state free of disease and/or genetic contamination.

DISADVANTAGES:

1. Wood Buffalo National park will continue to exist but without a large, free-roaming herd of bison during the disease eradication and replacement phases.
2. The procedure for elimination of the disease-exposed bison may not be readily accepted by certain public interest groups.
3. The predator-prey relationship may be negatively affected in the interim but this is not considered to be detrimental because wolf-bison relationships are likely to develop again once wood bison are reestablished in the Park (Messier 1989 - Compendium, Northern Diseased Bison Environmental Assessment Panel).

D. SUMMARY AND CONCLUSIONS

Agriculture Canada has presented a comprehensive, costed action plan to replace brucellosis and tuberculosis infected hybrid bison in and around Wood Buffalo National Park with healthy wood bison free of both diseases. The plan involves the systematic rounding up and humane slaughter of the diseased animals. Concurrently wood bison derived through annual contributions from the Mackenzie Bison Sanctuary and Elk Island National Park are multiplied in enclosures adjacent to and within the Park. The plan offers flexibility to enable mitigation of environmental and socio-economic concerns.

This proposal provides a solution to the disease problem for the livestock industry and would conserve a threatened subspecies of wildlife that is of national significance as a heritage resource. It would strengthen the World Heritage Site designation for Wood Buffalo National Park.

Reestablishment of a major population of disease-free wood bison into its original habitat into an area of permanent protection under the National Parks Act would be achieved. Native people will be able to participate in this important process and will benefit economically in both the short and the long term.

Potential disease problems for the livestock industry will have been eliminated, and in the long term, will save considerable monies, by reducing the cost of disease monitoring programs. Perpetuation of a national disease-free status will benefit the industry economically.

E. GLOSSARY

1. Abattoir/Cold Storage Facility

   A slaughter plant with freezers and coolers for storage of edible carcasses and portions.

2. Anthrax

   A fatal infectious bacterial disease of ruminants, swine and man associated with spore contamination of soil.

3. Baiting

   Luring of animals by use of food to an intended location.

4. Bison

   Plains, Prairie (*Bison bison bison*)

   Wood (*Bison bison athabascae*)

5. Brucellosis - Also called Bangs Disease and Contagious Abortion

   A bacterial infection which causes abortion, infertility, sterility and arthritis in cattle and bison. Causes undulant fever in humans.

6. Carrying Capacity

   The number of animals that a given area of land can sustain without causing ecological harm with particular reference to food production for the animals and habitat as well.

7. Commercial Plains Bison (Ranched Bison)

   Plains bison raised in captivity for commercial purposes. These are classified as domestic animals in Saskatchewan, Manitoba and Alberta and are regulated by Agriculture. They are not classified as wildlife in the above provinces.

8. Controlled Hazing

Moving animals in a particular direction and to a particular destination without close chasing.

9. Darting

Using a projectile syringe to tranquilize a wild animal to allow its manipulation with a minimum of stress.

10. Depopulation

Remove all animals from a site by slaughter. Animals may be removed live, followed immediately by slaughter at an abattoir.

11. Disease-Exposed Bison

Bison which have been exposed to the bacteria of brucellosis and/or tuberculosis and thus are potentially infected.

12. Disturbed Areas

Areas which have been altered from their original natural state by previous construction of fences, buildings, roads, or by introduction of vegetative species other than native.

13. Double Fenced Compounds/Enclosures

Areas enclosed by two fences parallel to one another. This provides a zone where no contact can occur between animals within the fenced area and any animals on the outside. This increases the security of confinement.

14. Endangered Species List

A list of animal and plant species whose survival is threatened for continued survival. This list is compiled by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), a federal-provincial group established in 1977.

15. Federal Standard

Standards developed in response to section 20 of the Meat Inspection Act, which governs the design, construction and maintenance as well as the equipment used in a registered establishment (abattoir under Federal Inspection). In addition, it covers prescribing the equipment and facilities to be used, the procedures to be followed, and the standards to be maintained in the registered establishment, to ensure humane treatment and slaughter of animals, and hygienic processing and handling of meat and meat products.

16. Federal Inspection

Inspection that ensures federal standards are met. Inspections are carried out by Federally appointed inspectors.

17. Field of Genetics and Taxonomy

The study of inherited characteristics (genetics) and the systematic classification of animals and plants (taxonomy).

18. Game Farming

The maintenance and breeding of wild animals in captivity for commercial purposes excepting the sale of meat.

Game Ranching

Includes game farming and the sale of wild meat (which is not legally permitted in Alberta at present).

19. Ice Bridge

The frozen surface of a river adapted for the crossing by vehicular traffic, usually constructed by pumping water on a frozen surface to build ice layers of several meters in thickness.

20. Identified

An animal that is marked in a manner that can be distinguished from other individuals of the same species, usually by the use of a numbered metal eartag.

21. Phenotypic Assessment

Assessing physical characteristics which are represnted by phenotypic expression.

22. Phenotypic Expression

The set of external body characteristics such as size, shape, hair length and color that distinguish that species/subspecies from another. These traits are usually genetically controlled.

23. Rendering

The heat treatment designed to sterilize (kill bacteria in) carcasses and organs in order to use the product to make animal food or fertilizer.

24. Repopulation

The reintroduction of a species which has been previously eliminated from a defined area.

25. Tuberculosis

A bacterial disease which affects animals and man. The bovine form will infect man, bison and other animals.

26. Vegetation Succession

The change in state from one dominant plant community to another as determined by other environmental factors.

27. Viable Population

A healthy population which is capable of maintaining and/or increasing its numbers to a normal balance with the environment and is of sufficient sex ratio to ensure continued reproduction and growth in numbers.

CRITIQUE OF BUFFER ZONE, FENCING, COMPOSITE, AND STATUS QUO OPTIONS

This critique of some options considered in more detail by the Task Force is written in two parts:

Part i) Buffer Zone Option

- a) Grand Detour
- b) Yellowstone National Park

Part ii) Status Quo, Fencing, and Composite Options

i) Buffer Zone Option:

Is to contain diseases to Wood Buffalo National Park by establishing a buffer zone at least 320 km wide around the Park and maintain this zone clear of ruminants.

The basic flaw with this option is that buffer zones are known not to work.

a) Grand Detour - is a good example of the ineffectiveness of the buffer zone system that was tried in Wood Buffalo National Park area on bison.

On page 3-4 (early attempts at disease control) of Evaluation of Brucellosis and Tuberculosis in Bison in Northern Canada (Task Force Report) it is explained as follows:

"An outbreak of anthrax occured (1962) and became the focus of disease control. The epidemiology of anthrax was not completely understood by officials during the first outbreaks of the disease. Since the bison population east of the Slave River was believed to be mostly discrete, (ie: little interchange took place east and west across the Slave River), the government officials theorized that the spread of anthrax from east of the Slave River to bison in Wood Buffalo National park could be prevented by creating a "buffer zone" between the two populations. Therefore, an effort was made in 1964 and 1965 to depopulate the area between Little Buffalo and Slave Rivers (Grand Detour). During the winter of 1964-1965, 522 bison were slaughtered in that area. The action was ineffective; bison from Wood Buffalo National Park rapidly reinvaded the area, and anthrax outbreaks continued to occur, spreading eventually throughout the Slave River Lowlands and Wood Buffalo National Park".

b) Yellowstone National Park - uses a buffer zone and it has failed.

Boundary control is a better term to be used with regard to the effort at Yellowstone National Park and this is the terminology used in relation to that effort. Attempts to control the movement of bison within the Park into the surrounding agricultural community was proposed in 1968 as an alternative to controlling brucellosis infected bison within the Park.

In conversation with Dr. D.R. Ferlicka, DVM, State Veterinarian for Montana, the opinion was expressed that such control is a resounding failure.

Dr. Ferlicka was at the AAHA meeting in Kentucky as well as at the Bison conference at Missoula, Montana, September 1987. At these and other conferences he has discussed efforts to prevent the bison from contacting domestic stock, and the extra testing procedures required to ensure the livestock have remained disease free.

The boundary control program is done in cooperation with the State Fish and Wildlife people. There are three main bison groups in the Park, 1) Northern herds, 2) Mountain herds, 3) Hayden Valley herd. There are approximately 2,700 head in the Park and up to nine hundred of these migrated out in the past year. Dr. Ferlicka was of the opinion that a number of factors caused this great an exodus in this particular year. These factors were; the fire of 1988, the severe drought last summer affecting availablity to the forage and the large amount of snow and cold weather in the last winter. In the period from December to March some 300 animals were shot causing a large outcry from the public. His experience is that over 50 head usually triggers public attention.

Dr. Ferlicka referred to information on this which has been published by Dr. Mary Meagher of the National Parks Service, Yellowstone National Park, in the Wilderness Society Bulletin, Volume 17, pages 15 - 19, 1989, "Evaluation of Boundary Control for Bison of Yellowstone National Park". I enclose a copy of that publication and bring your attention to one sentence in the summary which says, "Efforts made since 1976 to contain bison within the boundaries of Yellowstone National Park proved to be ineffective". (see enclosure)

Dr. Meagher gives similar information in a report on the Yellowstone National Park bison herd at the North American Bison Workshop held in Missoula, Montana, September 9, 1987, and at that time indicated that boundary control was not successful.

She emphasized at that time, and reiterates it in her paper which is enclosed, that a number of bison develop or acquire a knowledge on migration, can contribute greatly to the movement of bison out of the Park. This has caused a continuing problem in that movements seem to be increasing.

There is no doubt that a similar type of acquired knowledge in the bison of Wood Buffalo National Park would also take place if a buffer zone was instituted.

Dr. Ferlicka's statement that a large public outcry occurred after the slaughter of a number of the animals that emigrated from the Park suggests that such a method of control would not likely be tolerated on a continued basis in Canada any more than it is in the U.S.A.

These examples all illustrate how the Buffer Zone Option would fail. It would fail to isolate either disease or bison.

In addition, one must consider that this is not required for just a month or two, this option must succeed for an indefinite time. If it fails - disaster when the Mackenzie bison herd is infected.

As pointed out on pages 5-42 of the Task Force Report, the tendency of bison to migrate would necessitate such a large area for a buffer zone that it would not be feasible. A zone of at least 320 km surrounding Wood Buffalo National Park would be required to effectively isolate the bison. This would extend generally south to Slave Lake, west to Hay Lake and north to Great Slave Lake. Effectively no susceptible animals would be allowed in this very large area, and all cattle and bison north of Manning, Alberta, would have to be removed.

It would be impossible to maintain effective surveillance of this extensive area to prevent animal movements out of the zone. If only a single bison crossed the buffer, the possibility of genetic contamination and the spread of brucellosis and tuberculosis would recur.

Agriculture is well established in the Fort Vermilion area, and livestock and cattle production is essential to farm viability. There is currently no legislation that would facilitate the removal of livestock and wildlife from such a designated area. Governments would be unlikely to consider any enabling legislation because of:

- the negative reaction from the agricultural lobby.
- the poor chance of a buffer zone succeeding.
- the tremendous amount of land being set aside to maintain a declining herd of less than 5,000.
- this large area for the buffer zone would restrict future range extension by the Mackenzie Bison Sanctuary wood bison population.
- there would continue to be a risk to the health of persons in contact with bison from Wood Buffalo National Park.

- this option does not address the objectives (pages 1-6 Task Force Report) of any of the six government agencies involved in the Task Force except Canadian Parks Service.
- surveillance costs would be continued for as long as these bison existed, or until the option failed.
- other species of animals would also have to be eliminated in this buffer zone to prevent secondary carriers from spreading these diseases.

ii) Status Quo, Fencing and Composite Options

a) Status Quo

This option maintains the present situation without additional management action by Wood Buffalo National Park, but with acknowledgement that other agencies may be required to take independent action within their own jurisdictions.

This option shows no concern for the wood bison situation. It already forced the Department of Renewable Resources, Government of the Northwest Territories to set up a buffer zone to prevent contact with diseased hybrids. This is at best a stalling tactic and acknowledged to be a failure with time.

All members of the task force agreed that the wood bison of the Mackenzie Bison Sanctuary are in imminent danger of contacting diseased hybrids from Wood Buffalo National Park. Three bison have been seen thirty miles north east of Enterprise on the highway. Dr. Cormack Gates has documented the rapid movement of far ranging bulls back to the center of the Sanctuary. It is just a question of time before this contact occurs. Then the largest herd of free roaming wood bison (more than 2/3 of the population of a threatened sub species) will be infected with tuberculosis and brucelosis and hybridized. This would be a national disgrace.

Under the Status Quo Option the Wood Bison Recovery Program would be destroyed as all of the potential wood bison range would be threatened by this diseased herd of hybrids in the center of that historic range.

This option would hinder the estalishment of game ranching in the area and rquire increased expense and effort to keep game ranch species, particularly bison, from becoming infected with tuberculosis or brucellosis. Should that occur the depopulation and cleaning and disinfection required would result in damaging publicity for the entire national game ranching industry.

The Agricultural Industry would continue to have grave concerns about the possibility of livestock contracting either or both of these diseases. Alberta Agriculture is unlikely to curtail the encroachment of agriculture up to the Park boundry, resulting in rising tension between ranchers/-farmers in the area and the Park over possible disease transmission. This nidus of infection would be expected to be used more and more by importing countries to limit importation of products and livestock from Canada. This would receive more attention as these countries become disease free.

Agriculture Canada and Alberta Agriculture will have to maintain their disease surveillance and prevention programs in the field and in packing plants at considerable costs. (The cost to Agriculure Canada for surveillance in northern Alberta will increase from the $355,000 now spent annually in proportion to the rate of agriculture expansion in the area).

- As with the Buffer Zone Option, none of the six government agencies involved with the Task Force objections would be met with the exception of Canada Parks Service.

- The Wood Bison Recovery Program would be destroyed.

- A small population of diseased hybrid bison would occupy a tremendous amount of ideal range.

- The risk to human health would continue to be present.

b) Fencing Option

The infected bison populaton would be contained within the Park by a double fence around the Park perimeter. An ongoing maintenance and surveillance program would be required to ensure that the fence continued to prevent the escape of potentially diseased animals from the Park area. All diseased hybrid animals outside the fence would be eliminated.

There are two very big problems with this option:

1. Is it possible to fence the Park entirely - big problems fencing across rivers like the Peace River, fencing large lakes like Buffalo Lake?

2. Is it possible to maintain such a fence completely and continuously in this type of environment - fires - muskegs - moving ice; so it will never allow a bison to escape, as once this happens the whole project fails?

The costs would be very high. It is estimated to cost $30,000,000 to complete, $70,000/year to monitor and maintain, and will require replacement in 30 years at a cost of $12,000,000.

This does not count the cost of eliminating all diseased hybrid bison outside the Park.

The fence would interfere with traplines, wildlife movement such as moose and woodland caribou, and access to points to the Park. Fencing of rivers such as the Peace will require approval from Transport Canada and the Navigable Waters Act.

Technical and logistical problems caused by difficult terraine conditions will greatly increase estimated construction and operational costs and could seriously affect the overall feasibility of the Fencing Option

Even with a double fence, there will always be a risk that breaks could occur in both fences. If that happens and diseased bison escape, the original purpose of the fence is defeated.

c) The Composite Option:

Combines elements from several other options in an attempt to confine tuberculosis and brucellosis to Wood Buffalo National Park. This option would involve buffer zones and fencing in strategic areas. No bison would be tolerated west of the Park boundary on Alberta land or north of the Park between the Park boundary and the Mackenzie River. Both hybrid and wood bison would have no protected status in these areas. All diseased hybrid bison outside the Park would be eliminated.

This option is fraught with danger. It amounts to doing an incomplete job of either the buffer zone or the fencing option. (The buffer zone option is not expected to work even when implemented completely; thereby it is even less likely to succeed if it is in only partial use). The whole key to the fencing option's success is that it must be kept intact - with this option we are only spot fencing heavy use areas. This seems to suggest that these are the only areas used and bison will not change their movement patterns. The fencing portions also go through the same problems already outlined in the fencing option, including fencing lakes, muskegs, etc., surveillance and maintaining fences.

We must again emphasize that if one bison escapes, all efforts have been for nothing, and once the Mackenzie Bison Sancuary is infected, the problem is over such a large area that the disease problem will essentially be out of control.

This option interferes with the Wood Bison Recovery Program as wood bison could not be returned to all areas of their historic range. The government of the Northwest Territories would have to restrict expansion of the Mackenzie Bison Sanctuary and the Nahanni-Liard herds and may have to re-evaluate their current management plans for the existing herd in Slave Rive Lowlands. The Hay-Zama project in northern Alberta would be re-evaluated. The present Agriculture Canada surveillance programs would have to be maintained to verify that disease had not spread to livestock in that area.

The cattle industry would be skeptical that their concerns were being dealt with effectively.

Environmental groups may react negatively to large bison free areas to the active elimination patrols, and to the hunting of wood bison in the buffer zone.

Agriculture development could not be allowed in the area surrounding the Park, and some risk would still remain that bison could contact livestock or game-farmed animals.

The general licensed public would be allowed to hunt in the Northwest Territoiries part of the buffer zone. This would increase the number of people at risk from handling or consuming diseased bison.

SUMMARY:

Reasons why the Buffer Zone, Status Quo, Fencing, Composition Options would fail include:

1. The fact that if one diseased animal escapes and makes contact with the Mackenzie Bison Sanctuary all efforts, money, and the time spent to that point are wasted. This would result in the problem expanding over such a large area that solutions may never be possible.
2. These options would have to be 100% effective for perpetuity. Almost successful for most of the time is a failure.
3. Buffer zones have never been known to succeed. (Not in Grand Detour, not in Yellowstone [much easier environment and access], not in Australia).
4. It is recognized by all government agencies participating in the Task Force that the problem is urgent.
5. All these options prevent future range extension by the Mackenzie Bison Sanctuary, Nahanni-Laird, and the Hay-Zama wood bison herds, effectively preventing wood bison from occupying a large area of their historic range.
6. None of these options address the objectives (pages 1-6 Task Force Report) of any of the six government agencies involved in the Task Force except the Canadian Parks Service.
7. The expense of the Fencing Option is prohibitive - $30 million initial construction; $70,000 annual maintenance and surveillance; and $12 million replacement costs every 30 years. This does not include the cost of eliminating the bison outside the fence, or of special problems due to adverse terrain.
8. Under all these options, game ranching of bison in the area would be in danger. Infection of such a ranch would result in depopulation of that ranch and damage to the industry as a whole through the bad publicity of diseased meat.
9. At a minimum, Agriculture Canada would be required to maintain disease surveillance of northern Alberta at the present cost of about $355,000/year.
10. Export markets for Canadian livestock and livestock products would always be compromised because of the presence of disease in the Wood Buffalo National Park area.
11. A small number of unproductive diseased hybrid bison would be occupying a very large area (70,000 square miles) (much more if one included the buffer zone) area of potential agricultural land.

12. With all but the fencing option the risk of these diseases to human health would continue.

13. The Fencing Option requires overcoming very big obstacles - fencing rivers, lakes, mountains and muskeg. It requires keeping fences intact at all times, in spite of ice flows, forest fires, frost heaves, and interfering with trap lines.

14. All these options would interfere with animal movement - moose, woodland caribou and healthy bison.

15. With the Composite and Buffer Zone Options, environmental groups would react to large bison free areas, to the active elimination patrols, and to the hunting of wood bison in the buffer zone.

16. The Composite and Buffer Zone Options would limit agricultural growth and even require livestock producers and game ranchers to be uprooted.

17. The Status Quo, Composite, and Buffer Zone Options will not alleviate the agricultural industry's grave concerns about livestock contracting these diseases.

One has to question the motives of anyone supporting any of these options (Status Quo, Fencing or Composite). In light of the likelihood of failure are the proponents of these options actually supporting options they know will fail so the situation will be hopeless and everyone will go away and leave them alone?

It should be pointed out that the value of this hybrid herd may be somewhat overstated. It is a diseased hybrid herd of less than 5,000 animals. There are over 100,000 plains bison in North America, so their significance here is very minor indeed. It is a free ranging herd but not the only one. The Mackenzie Bison Sanctuary is a free ranging herd and so is the Yellowstone National Park herd. The Yellowstone herd is also made up of some animals that were the original free ranging bison of that area.

The meat provided for local natives by the Wood Buffalo National Park herd, apart from being dangerous to their health, is insignificant in quantity. Note that one bison ranch in Grande Prairie - the Adam Ranch, produces 15 times the estimated hunt of the Wood Buffalo National Park herd (estimate 60 head/year from Wood Buffalo National Park and Adam Ranch markets 1,000 head/year).

There probably is some wood bison genetic diversity in the Wood Buffalo National Park herd. However, with nearly as many wood bion outside Wood Buffalo National Park as there are diseased hybrids in Wood Buffalo National Park, no one with wood bison interests at heart would sacrifice the entire wood bison range and future to maintain this diversity with disease.

The unanimous voice of the Task Force and all agencies involved stated on pages 5-54 of their report:

"The urgency of the situation is apparent. In the very near future regardless of the work of the Steering Committee, other agencies may be forced to take steps indepndently to protect the Mackenzie Bison Sanctuary herd from contacting the hybrid diseased animals in and near Wood Buffalo National Park. It is acknowledged that this contact could occur at any time, and should it occur, the bison disease problem may expand to such proportions that solutions may never be possible".

Surely under the Replacement Option we have nothing to lose and everything to gain.

TRANSMISSION OF BOVINE BRUCELLOSIS AND TUBERCULOSIS FROM BISON TO CATTLE

S.V. Tessaro, MSc, DVM, PhD
Health of Animals Laboratory
116 Veterinary Road
Saskatoon, Sask. S7N 2R3

Bovine brucellosis and tuberculosis are readily transmitted from bison to bison. This has been repeatedly indicated by the fact that bison populations can, in and of themselves, transmit and maintain these diseases over successive generations -- a basic characteristic of a true primary reservoir species. Intraspecific transmission of the diseases has occurred in bison populations in zoos, game farms, game preserves, and national parks (Tessaro 1989), and under experimental conditions (Davis _et al_ in press). That infected bison from the Wood Buffalo National Park region are capable of transmitting brucellosis and tuberculosis to the bison from the Mackenzie Bison Sanctuary is scientifically irrefutable. Transmission of brucellosis and tuberculosis from bison to other wild ungulates (elk, mule deer, and moose) sharing the same habitat has also been documented (Hadwen 1942, Corner and Connell 1958, Tessaro 1987).

Field and experimental studies have shown that the pathology, pathogenesis, and epidemiology of bovine tuberculosis is the same in bison and cattle (Thoen _et al_ 1984, Tessaro 1987, Thoen _et al_ 1988). Cattle that were penned with experimentally infected bison calves developed positive tuberculin skin test responses, and the researchers felt that _M. bovis_ would likely have been recovered from the cattle if more than one of the infected bison calves had developed lung lesions (Thoen _et al_ 1988). The last major outbreak of bovine tuberculosis in the United States occurred in 1984-85; the disease was spread by infected bison from two ranches in South Dakota to 21 bison herds in 10 states, and resulted in the slaughter of 2,086 bison, 878 cattle, and 42 swine and goats (Essey 1984, Stumpff _et al_ 1984, Essey and Stumpff 1985).

Transmission of bovine brucellosis from bison to cattle has occurred under experimental and field conditions. Davis _et al_ (in press) have shown that experimentally infected bison can transmit brucellosis to cattle and other bison held in the same paddock. Dr. Davis (Professor of Veterinary Pathology, Texas A&M University) has presented this and other information on brucellosis in bison to the Northern Diseased Bison Environmental Assessment Panel, at their request. There was documented transmission of _Brucella abortus_ from a privately-owned bison herd to range cattle in North Dakota (a brucellosis-free state) in 1983, which resulted in depopulation of the two herds (United States Committee on Brucellosis 1983). It is noteworthy that _B._

abortus biovar 1 was isolated from these bison and one of the cattle; this biovar occurs in bison in and around Wood Buffalo National Park.

In 1988-89, transmission of B. abortus from free-ranging bison and/or elk to cattle occurred in Wyoming (Thorne pers. comm., Thorne et al 1989). Bison from the infected Jackson Hole herd were seen on pasture with the cattle. Strong circumstantial evidence was obtained in two earlier outbreaks of brucellosis in Wyoming cattle that pointed to bison and/or elk as the source of infection. Thorne et al (1989) reported that, "The threat of bison to cattle transmission [of brucellosis] is real", and that, "The effects of brucellosis in bison and elk are similar to those of cattle, and brucellosis can be transmitted among these three species". Dr. Thorne (State Wildlife Veterinarian, Wyoming Game and Fish Department) gave this information to the Northern Diseased Bison Environmental Assessment Panel, at their request, in a meeting in Edmonton.

Forbes et al (in preparation) have experimentally shown that B. abortus biovar 1, isolated from a bison in Wood Buffalo National Park, is infectious and virulent in cattle, and that infected cattle could transmit the disease to other cattle.

References

Corner AH, Connell R. Brucellosis in bison, elk and moose in Elk Island National Park, Alberta, Canada. Can J Comp Med 1958; 22: 9-21.

Davis DS, Templeton JW, Ficht TA, Williams JD, Kopec JD, Adams LG. Brucella abortus in captive bison. I. Serology, bacteriology, pathogenesis, and interspecific transmission to susceptible Bos taurus heifers. J Wildl Dis 1989 (in press).

These data were also presented by Dr. Davis at the 36th Annual Conference of the Wildlife Disease Association, Lincoln, Nebraska. August 2-5, 1987.

Essey MA. Bovine tuberculosis in bison. Proc US Anim Health Assoc 1984; 88: 583-585.

Essey MA, Stumpff CD. Report on the bovine tuberculosis outbreak in bison in the United States. Proc US Anim Health Assoc 1985; 89: 450-457.

Forbes LB, Tessaro SV, Lees W. Experimental studies of Brucella abortus, isolated from a bison in Wood Buffalo National Park, in cattle. In preparation.

Hadwen S. Tuberculosis in the buffalo. J Am Vet Med Assoc 1942; 100: 19-22.

Stumpff CD, Essey MA, Person PH, Thorpe D. Epidemiologic study of M. bovis in American bison. Proc US Anim Health Assoc 1984; 88: 564-570.

Tessaro SV. A descriptive and epidemiologic study of brucellosis and tuberculosis in bison in northern Canada. PhD Thesis, University of Saskatchewan, 1987. xxi + 320 pp.

Tessaro SV. Review of the diseases, parasites and miscellaneous pathological conditions of North American bison. Can Vet J 1989; 30: 416-422.

Thoen CO, Throlson KJ, Miller LD, Himes EM, Morgan RL. Pathogenesis of Mycobacterium bovis infection in American bison. Am J Vet Res 1988; 49: 1861-1865.

Thoen CO, Karlson AG, Himes EM. Mycobacterium tuberculosis complex. In: Kubica GP, Wayne LG, eds. The Mycobacteria: a Source Book, Part B. New York: Marcel Dekker Inc., 1984: 1209-1235.

Thorne ET, Meagher M, Hillman B. Brucellosis in free-ranging bison: three perspectives. 38th Annual Conference of the Wildlife Disease Association, Corvallis, Oregon. August 13-17, 1989.

United States Committee on Brucellosis. A case history of a brucellosis outbreak in a brucellosis-free state which originated in bison. Proc US Anim Health Assoc 1983; 87: 171-172.

S.V. Tessaro
November 7, 1989

SYNOPSIS AND LITERATURE:

ZOONOTIC ASPECTS OF Brucella abortus AND Mycobacterium bovis WITH SPECIAL CONSIDERATION OF THE RESERVOIR OF BRUCELLOSIS AND TUBERCULOSIS IN BISON IN AND AROUND WOOD BUFFALO NATIONAL PARK

Stacy V. Tessaro, M.Sc., D.V.M., Ph.D.
Health of Animals Laboratory
Agriculture Canada
116 Veterinary Road
Saskatoon, Saskatchewan
S7N 2R3

November, 1989

Page

Historical Perspective 2

Current Perspective 4

Public Health Considerations Regarding Bovine Brucellosis and Tuberculosis in Bison in and Around Wood Buffalo National Park 5

Literature: (A) Zoonotic Aspects of Brucella abortus 9

(B) Zoonotic Aspects of Mycobacterium bovis 19

"The work conducted by the Health of Animals Division of the Dominion Department of Agriculture is for the benefit of the livestock industry, but it also has a definite relation to public health."

- Dr. A.E. Cameron, 1938
Can Public Health J 29: 262

"Effective control of brucellosis leading to local eradication, which could be national in scope, is biologically feasible. Physicians have a responsible role in this eradication."

- Dr. R.I. Wise, 1980
J Am Med Assoc 244: 2318

"The first country to eliminate tuberculosis will be that country which regards it as a serious problem right to the end."

- Dr. N.W. Horne, 1984
Br Med J 288: 1249

Historical Perspective

Brucella abortus and *Mycobacterium bovis*, the etiologic agents of bovine brucellosis and tuberculosis, have long been recognized as significant causes of disease in people. This is extensively documented in the medical literature (see attached list of references). Human infections were once common in developed countries, and are still prevalent in many third world nations.

Over 6,000 human cases of brucellosis were reported annually in the U.S. during the 1940's (Wise 1983), and serological surveys done in Canada between 1937 and 1951 indicated that 8.6-19.4% of people in rural areas were exposed to *B. abortus* (Baltzan 1937, Quintin and Stalker 1946, Snell 1950, Sanderson *et al* 1951). Although the incidence of chronic brucellosis in Canada was never measured, it was suggested that "it may well be that a very considerable volume of undiagnosed illness of a chronic type may be due to *Brucella* infections" (Editorial 1950).

Research in the U.S. indicated that only 3.5-10% of cases were reported (Wise 1980). Barrett and Rickards (1953) refer to U.S. studies that suggested that the number of chronic cases was 10 to 25 times greater than the number of acute cases reported to health authorities. Brucellosis has been misdiagnosed and under-reported because of the extreme variability of clinical signs, none of which are pathognomonic (Keane 1982), and because of inconsistencies in serological test response and difficulty in isolating the organism (Davies 1957, Kerr *et al* 1966, Williams

1970, Carpenter et al 1979). A high percentage of infections can be subclinical (Henderson and Hill 1972).

Some of the uncommon, but more clinically significant, manifestations of B. abortus infection in human cases include: heart disease, especially endocarditis (Harkness 1936, Rennie and Young 1936, Spink et al 1942, Quintin and Stalker 1946, Hart et al 1951, Grant and Stote 1953, Peery and Evans 1958, Peery and Belter 1960, Cleveland et al 1970, Pazderka and Jones 1982, Almer 1985); osteoarticular disease, especially of the spine, hip, and knee (Weed et al 1952, Kelly et al 1960, Glasgow 1976, Torres-Rojas et al 1979, Abrahams and Tylkowski 1985, Alarcon et al 1987, Ferris 1987, Goodhart et al 1987); central nervous system disease, including meningitis and meningoencephalitis (Spink and Hall 1949, Nelson-Jones 1951, Nichols 1951, Fincham et al 1963, Bouza 1987, Weissenborn et al 1987, Pascual et al 1988); liver disease (Hewlett and Ernstene 1947, Spink 1949, Barrett and Richards 1953, Williams and Crossley 1982); orchitis/epididymitis (Isaac 1938); empyema (MacDonald 1939); abortion (Carpenter and Boak 1931, Smith et al 1982). The overall case fatality rate was estimated to be 1-2% (Spink 1956, Bothwell 1960).

In the 1930's, a worldwide survey of 18,000 mycobacterial isolates from human cases of tuberculosis estimated that 10% were caused by M. bovis infection (Price 1939). Similar figures were obtained in individual countries: 12% of 5,476 human cases in Denmark (Jensen et al 1940); 12% of 714 cases in the Netherlands (Ruys 1939); 15% of 2,278 cases in Germany (Meissner and Schroder 1974); 12% of 1200 cases in the U.S.A. (Kleeburg 1965); 10% of 320 cases in Canada (Price 1932). These figures alone, based on general population, do not reflect the facts that M. bovis infection was more common in children than adults, and that rural populations often had a higher prevalence of the disease than did urban communities. In man, M. bovis more frequently causes extrapulmonary disease (cervical lymphadenitis, osteomyelitis/arthritis, meningitis, and abdominal tuberculosis) than the human variant of the bacillus. However, it was well recognized that M. bovis could affect any organ system, and the disease was clinically and pathologically indistinguishable from M. tuberculosis infection (Griffith 1932, 1937).

In 1939, approximately 25-30% of deaths due to non-respiratory tuberculosis, and 1-2% of deaths due to respiratory tuberculosis, were attributed to M. bovis infection in Britain (Clarke 1952). Wilson (1942) estimated that bovine tuberculosis killed 1,500 to 2,000 people, mainly children, annually in Great Britain. In Scotland, 3,000 to 4,000 cases of surgical tuberculosis due to M. bovis infection were reported annually during the 1940's (Wilson et al 1952). A study of 67 human cases bovine tuberculosis reported a case fatality rate of 42% (Hedvall 1942) during the study period.

Bovine brucellosis and tuberculosis were widely disseminated in human populations via consumption of raw milk and dairy products from infected cattle (Ravenel 1941, Magoffin et al 1949, Galbraith and Pusey 1984). The medical profession recognized that pasteurization of milk would reduce the magnitude of the problem but would not eliminate it, especially in people that are occupationally exposed to the diseases via other routes of infection: farmers, livestock workers, dairy processors, abattoir workers, meat inspectors, rendering plant employees, butchers, veterinarians, and laboratory workers. Compliance with pasteurization requirements could not be guaranteed, especially in farm families and rural communities, when there was a high incidence of both diseases in cattle. Consequently, the double approach -- pasteurization and implementation of animal health programs -- led to a dramatic and rapid decline in the incidence of the two diseases in human populations in western developed countries.

Current Perspective

Sporadic cases of bovine brucellosis and tuberculosis still occur in Canada and other developed countries. Brucellosis is mainly an occupational disease of people who handle and process infected animals; foodborne transmission has been superceded by inhalation, cutaneous, and conjunctival exposure to the pathogen in developed countries (Blegvad 1935, Levine 1943, Jordan 1948, Magoffin et al 1949, Danon et al 1950, Hendricks et al 1962, Boycott 1964, Fish 1964, Schnurrenberger et al 1972, Alton and Gulasekharem 1974, Buchanan et al 1974, White et al 1974, Cayton et al 1975, Fox and Kauffman 1977, Allwright and Murphey 1979, Gilbert et al 1980, Kauffman et al 1980, Davos et al 1981, Jamieson et al 1981, W.H.O. 1981, Alleyne et al 1986, Martinez de Cortinez et al 1986, Pal and Jain 1986, Peelman and Dekeyser 1987). Modern epidemiologic studies suggest that "contact with infected animals is much more important than consumption of raw milk in the spread of this disease" (Editorial 1983 -- see also Magoffin et al 1949, Boycott 1964, Alton and Gulasekharem 1974, Flynn 1983).

Wigle et al (1972) reported 31 active cases of bovine tuberculosis in people in Ontario detected between 1964 and 1970; most were attributed to recrudescence of the disease acquired during childhood. Enarson et al (1980) mention these same cases plus 30 more from Ontario and British Columbia identified between 1964 and 1976; hence 61 (0.42%) of 14,417 cases of tuberculosis detected in those two provinces during that period were due to *M. bovis* infection.

Surveys done between 1977 and 1987 in England found that 1.2 - 1.4% of human cases of tuberculosis were attributable to classical strains of *M. bovis* (Collins *et al* 1981, Yates *et al* 1986, Yates and Grange 1988). Based on epidemiological considerations, the authors suggest that many of these persons acquired the disease via respiratory infection, as a result of human-to-human transmission. Several other cases of pulmonary tuberculosis due to *M. bovis* infection, usually with bacilli present in sputum, have been reported in the literature (Griffith 1932, Cumming and Forster 1933, Griffith and Monroe 1933, Chievitz 1935, Ruys 1939, Hedvall 1942, Griffith and Monroe 1944, Cutbill and Lynn 1944, Kleinschmidt 1958, Kataria 1969, Dreesen and Wood 1970, Damsker *et al* 1974, Wilkins *et al* 1986), and circumstantial evidence of human-to-human, and human-to-cattle, transmission of *M. bovis* have been reported (Plum 1935, Hedvall 1942, Magnusson 1942, Tice 1944, Baldwin 1968, Black 1972, Wigle *et al* 1972, Werner 1981, Collins *et al* 1982, Jorgensen *et al* 1985, O'Donohue *et al* 1985, Collins and Grange 1987).

Both *M. bovis* and *M. tuberculosis* infections in humans are detected and treated by the same methods. This convenience has often resulted in failure to attempt to differentiate the two (Collins and Grange 1987, Pritchard 1988). Bacteriological identification of isolates is essential in determining the source and epidemiological significance of the infection. Cases of mixed infection (*M. bovis* and *M. tuberculosis*) have been reported (Jensen and Kiaer 1938, Jensen and Lester 1941, Griffith and Munro 1932 & 1944). Some strains of *M. bovis* isolated from human cases have shown resistance to p-aminosalicylic acid (PAS), isoniazid, or both (Kataria 1969). *Mycobacterium bovis* is resistant to pyrazinamide (Jones and Silva 1982, Grange and Collins 1987), and in one report a strain was found that was resistant to multiple anti-tuberculosis agents (Habib and Warring 1966).

Public Health Considerations Regarding Bovine Brucellosis and Tuberculosis in Bison in and Around Wood Buffalo National Park

Canada's livestock population was declared free of bovine brucellosis in 1985, and will be free of bovine tuberculosis in the very near future. The animal health benefits and associated economic gains to the livestock industry have increasingly offset the great cost and effort required to complete the lengthy eradication campaigns against these diseases. There have also been public health benefits from eliminating these zoonotic diseases. The hybrid bison population in and around Wood Buffalo National Park is the final, uncontrolled reservoir of bovine brucellosis and tuberculosis in Canada. These animals pose a health threat to livestock and other bison herds in the region.

Public health considerations in this situation are of two kinds: a) the direct risk of transmission of brucellosis and tuberculosis to native subsistence hunters who kill and butcher infected bison, and to other persons who handle infected bison carcasses or meat; b) the risk of indirect transmission to people via outbreaks of the diseases in cattle that result from contact between infected bison and livestock.

Strains of B. abortus and M. bovis isolated from bison in the Park region were morphologically and biochemically similar to field strains isolated from cattle and to standard laboratory reference strains (Tessaro 1987). Regarding the health of bison hunters, the question is not whether these pathogens from bison can produce disease in these people, but whether there is opportunity for transmission. In my recent survey (Tessaro 1987), 24 (43%) of 56 bison that were killed and butchered by hunters had one or both of the diseases. These people did not wear gloves or take any other special precautions when processing the viscera and meat of bison. Hunters were seen puncturing hygromas and arthritic joints, opening subcutaneous abscesses, and cutting open caseous lymph nodes, and then getting the contents of the lesions on their hands and knives, and on the meat. Brucella abortus and/or M. bovis were subsequently isolated from these lesions. Gravid uteri were usually cut open, either inadvertantly during butchering or out of curiosity after removal.

In most cases, bison with brucellosis had few, or no, gross lesions that would allow hunters to identify infected bison in the field. Hunters claimed that they selectively killed bison that were in good body condition and could identify, and reject, bison carcasses that had advanced, generalized tuberculosis. I found that these people overlooked advanced tuberculous lesions in lymph nodes, even though they frequently cut open affected retropharyngeal lymph nodes when disarticulating the atlanto-occipital joint to remove the head from a carcass. Hunters did not know, or believe, that these are zoonotic diseases.

Abattoir workers, and other persons occupationally exposed to infected cattle, have contracted brucellosis from infected animals via cutaneous, conjunctival, and aerosol exposure (Wise 1983). These routes of infection have also been documented in cases of brucellosis resulting from accidental mishandling of Strain 19, the attenuated vaccine strain of B. abortus (Sadusk and Born 1957, Revich et al 1961, McCullough 1963, Pivnick et al 1966, Gulasekharem 1970, Montes et al 1986). Since B. abortus has a similar distribution in body tissues of bison and cattle (Tessaro 1987), it is likely that the risk of infection for bison hunters is similar to that of abattoir workers. Brucella abortus infections have been reported in hunters that killed and butchered wild hogs (Bigler et al 1977, Abrahams and Tylkowski 1985, Currier 1989), and Brucella suis biovar 4 infections occur in Canadian subsistence hunters and their families who kill and process wild caribou (Tessaro and Forbes 1986).

Hunters are at greatest risk when butchering bison that have infected reproductive tracts (uterus, uterine contents and discharge, testicles and epididymides), or when cutting infected lymph nodes, or puncturing hygromas and arthritic joints (Alton and Gulasekharem 1974, Eze 1981, Tessaro 1987, Currier 1989).

Brucella abortus does not localize in muscle, but has occasionally been isolated from raw meat (Leresche et al 1957, Sadler 1960, Prost 1963, World Health Organization 1981) and was found on the hands of a butcher handling infected beef (Uche and Agbo 1985); these instances likely resulted from the presence of residual blood in meat from bacteremic animals. Wise (1983) therefore indicated that, "There is potential exposure of all people who handle the meat or meat products [from infected cattle]". However, there is little risk of infection from eating meat from infected cattle because: bacteremia is very short-lived in infected animals; animals killed in abattoirs are thoroughly exsanguinated; when meat is properly processed, the drop in muscle pH is usually sufficient to kill residual brucellae; the infective oral dose of B. abortus for humans is high, whereas the numbers of organisms occasionally found in raw meat is low; most meat is sufficiently well cooked by consumers to kill any brucellae that might be present. There have not been any documented cases of brucellosis attributed to consumption of infected meat. The safety of beef likely pertains to bison meat as well, although field-dressed bison are not thoroughly exsanguinated, and the meat is rapidly frozen thereby preserving any brucellae that might be present (Ivanova 1960).

Under current circumstances, there is opportunity for transmission of B. abortus from infected bison to hunters. Brucellosis may not have been reported in these people because: most human infections are asymptomatic or produce non-specific signs and symptoms that are rarely life-threatening; definitive diagnosis of the disease in people can be difficult; the group of people at risk is small and consists of individuals who rarely seek professional medical services; there has been no routine or special surveillance for brucellosis in the population at risk. When I was living in Fort Smith, N.W.T., I tried to initiate a serological survey for brucellosis in native hunters, through the cooperation of Dr. John Wezelman at the local hospital. Arrangements were made for blood sampling and serum testing, and a consent form was drafted. However, local hunters were not interested in being tested.

There has been circumstantial evidence of aerosol transmission of M. bovis from live cattle to farmers and others who have been in close contact with the animals (Griffith 1937, Ruys 1939, Jensen et al 1940, Hedvall 1941, Sigurdsson 1945).

Similarly, there has been a report of three people who converted from negative to positive status on Mantoux Test after being in contact with tuberculous elk (Stumpff 1982). Conjunctival tuberculosis occurred in farm workers (Blegvad 1935, Wilkins *et al* 1986), and was attributed to people wiping their face with contaminated hands or perhaps by the whipping of a cow's tail. *Mycobacterium bovis* was isolated from wash water used to clean the hands of a meat inspector and several abattoir workers (Hermansson 1939), and primary inoculation tuberculosis of the hands ("butcher's wart") due to *M. bovis* infection was once common in people handling infected cattle carcasses (Savage 1929, Lange 1937, Saenz and Fatio 1938, Verne *et al* 1952, Worthington 1964, Kleeberg 1975, Wilkins *et al* 1986). There is one report of primary skin tuberculosis (*M. bovis*) in a person handling an infected horse that had skin lesions (Huitema 1970). It is noteworthy that primary inoculation tuberculosis of the skin, caused by either *M. bovis* or *M. tuberculosis* ("prosector's wart"), rarely leads to systemic tuberculosis, but may cause positive reactions on intradermal skin tests for tuberculosis (Rich 1951, Goette *et al* 1978).

There is likely less risk of transmission of *M. bovis* than of *B. abortus* from bison to hunters. These people preferentially kill bison that are in good body condition and they reportedly reject carcasses with generalized tuberculosis. There is almost no risk of aerosol exposure and small risk of conjunctival exposure. Their greatest opportunity for infection with *M. bovis* would occur when they cut open affected lymph nodes, and the most likely route of infection would be by accidental inoculation of cuts and abrasions on the hands. This probably would not result in clinical or systemic disease, although is could produce positive tuberculin test results. I do not know if this is a confounding factor ("false positive") in routine tuberculosis surveillance in these people.

Francis (1973) reviewed the issue of food safety regarding meat from tuberculous cattle and concluded that there was little risk of human infection because: *M. bovis* is seldom present in muscle or residual blood; the infective oral dose for adult people is quite high; most meat is adequately cooked to kill any mycobacteria that might be present. When *M. bovis* was isolated from meat, it was usually due to surface contamination with exudate or caseous material from cutting utensils. There has been a high rate of recovery of *M. bovis* from meat of cattle with generalized tuberculosis (Kleeberg 1975). Although hunters butcher bison in a less hygienic manner than would be done in an abattoir, there is likely little risk of human infection from handling the meat of animals having only localized lesions, or from eating the cooked product. No cases of tuberculosis in people have been reported that were attributed to consumption of infected meat.

There are potential public health implications if bovine brucellosis and tuberculosis spread beyond the currently-infected bison population. Spread to other bison herds, especially to the Mackenzie Bison Sanctuary population, would nearly double the size of the enzootic zone and would expose additional hunters to the two diseases. The Fort Smith Hunters and Trappers Association has received funding and approval to start construction of a commercial bison ranch in an area of the Slave River Lowlands where free-ranging, diseased bison are known to occur. Transmission of brucellosis and tuberculosis to these captive bison might pose a future health risk for ranch workers and other persons handling or processing the bison.

Spread of the diseases to nearby cattle would result in occupational exposure of people in contact with the infected cattle and their products. The human health concern would be similar to any other outbreak of these diseases in livestock, and the magnitude of the problem would depend on how quickly infected cattle were detected and how far the diseases had spread. Any outbreak in cattle will be costly for affected farmers, the livestock industry, and agricultural agencies.

Literature: (A) Zoonotic Aspects of Brucella abortus

Abrahams MA, Tylkowski CM. Brucella osteomyelitis of a closed femur fracture. Clin Orthop 1985; 195: 194-196.

Acha PN, Szyfres B. Zoonoses and communicable diseases common to man and animals. Washington, D.C.: Pan American Health Organization Scientific Publication No. 354, 1980: 28-45.

Alarcon GS, Bocanegra TS, Gotuzzo E, Espinoza LR. The arthritis of brucellosis -- a perspective 100 years after Bruce's discovery. J Rheumatol 1987; 14: 1083-1085.

Alleyne BC, Orford RR, Lacey BA, White FMM. Rate of slaughter may increase risk of human brucellosis in a meat packing plant. J Occup Med 1986; 28: 445-450.

Allwright SPA, Murphey DL. Brucellosis in Irish meat workers. J Ir Med Assoc 1979; 72: 516-521.

Almer, LO. A case of brucellosis complicated by endocarditis and disseminated intravascular coagulation. Acta Med Scand 1985; 217: 139-140.

Alton GG, Gulasekharem J. Brucellosis as a human health hazard in Australia. Aust Vet J 1974; 50: 209-215.

Anonymous. Brucellosis in Britain. Br Med J 1984; 289: 817.

Baltzan DM. Experience with fifty-seven brucellosis infections in Saskatchewan. Can Med Assoc J 1937; 36: 258-262.

Barrett GM, Rickards AG. Chronic brucellosis. Q J Med 1953; 22: 23-42.

Bettelheim KA, Maskill WJ, Metcalfe RV, Pearce JL. The use of the microagglutination technique to determine the antibody status of healthy New Zealanders to Brucella abortus. J Hyg 1984; 92: 401-410.

Bigler WJ, Hoff GL, Hemmert WH. Trends of brucellosis in Florida: an epidemiologic review. Am J Epidemiol 1976; 105: 245-251.
Bothwell PW. Brucellosis: an anachronism in public health. Vet Rec 1960; 72: 425-430.

Bothwell PW. Epidemiology and prevention of human brucellosis. Vet Rec 1960; 72: 933-943.

Bothwell PW. Human and animal brucellosis. Recent studies and prospects for its control. (c) Endemiology of brucellosis in rural areas. Public Health 1961; 75: 274-285.

Bothwell PW. Brucellosis in children. Arch Dis Child 1962; 37: 628-639.

Bouvier G. Transmission possible de la Tuberculose et de la Brucellose du gibier a l'homme et aux animaux domestiques et sauvages. [Possible transmission of tuberculosis and brucellosis from game animals to man and domestic animals.] Bull Off Int Epizoot 1963; 59: 433-436.

Bouza E. Brucellar meningitis. Rev Infect Dis 1987; 9: 810-822.

Boycott JA. Undulant fever as an occupational disease. Lancet 1964; 1: 972-973.

Brodie J, Porter IA, Shanks PL, Mackenzie RM. Brucellosis in north-east Scotland. Health Bull 1970; 28: 26-31.

Buchanan TM, Faber LC, Feldman RA. Brucellosis in the United States, 1960-1972; an abattoir-associated disease. Part I. Clinical features and therapy. Medicine (Baltimore) 1974; 53: 403-413.

Buchanan TM, Sulzer CR, Frix MK, Feldman R. Brucellosis in the United States, 1960-1972; an abattoir-associated disease. Part II. Diagnostic aspects. Medicine (Baltimore) 1974; 53: 415-425.

Buchanan TM, Hendricks SL, Patton CM, Feldman RA. Brucellosis in the United States, 1960-1972; an abattoir-associated disease. Part III. Epidemiology and evidence for acquired immunity. Medicine (Baltimore) 1974; 53: 427-439.

Burnet E, Conseil E. *Brucella melitensis* and *B. abortus*. Their pathogenicity for man and monkey. Arch Inst Pasteur Tunis 1983; 60: 283-304.

Busch LA, Parker R. Brucellosis in the United States. J Infect Dis 1972; 125: 289-294.

Carpenter CM. Agglutinins for *Brucella abortus* in the blood of man. J Infect Dis 1926; 39: 220-223.

Carpenter CM, Boak RA. Isolation of *Brucella abortus* from a human fetus. J Am Med Assoc 1931; 96: 1212-1216.

Carpenter JL, Tramont EC, Branche W. Failure of routine methods in the diagnosis of chronic brucellosis. South Med J 1979; 72: 90-91.

Cayton HR, Osborne AD, Sylvester DGH. Exposure to *Br. abortus* in veterinary undergraduates and graduates. Vet Rec 1975; 97: 447-449.

Chukwu CC. Brucellosis in Africa. Part I: the prevalence. Bull Anim Health Prod Afr 1985; 33: 193-198.

Chukwu CC. Brucellosis in Africa. Part II: the importance. Bull Anim Health Prod Afr 1985; 35: 92-98.

Chung SC. Immunosuppression in chronic brucellosis. Ir J Med Sci 1978; 147: 103-107.

Cleveland JC, Suchor RJ, Dague J. Destructive aortic valve endocarditis from *Brucella abortus*: survival with emergency aortic valve replacement. Thorax 1970; 33: 312-315.

Cruikshank JC, Stevenson GA. Undulent fever. A small outbreak in a girls' school. Br Med J 1942; 1: 522-523.

Dalrymple-Champneys W. Undulent fever. A clinical review. Lancet 1932; 222: 791-793.

Currier RW. Zoonosis update: brucellosis. J Am Vet Med Assoc 1989; 195: 595-597.

Dalrymple-Champneys W. Undulent fever. A clinical review. Lancet 1932; 222: 791-793.

Dalrymple-Champneys W. Undulent fever. Lancet 1932; 222: 994-995.

Dalrymple-Champneys W. A study of the epidemiological aspects of undulent fever in this country, based on nearly 900 cases. Public Health 1948: 1-5.

Dalrymple-Champneys W. Undulent fever: a neglected problem. Lancet 1950; 258: 429-435, 478-485.

Dalrymple-Champneys W. *Brucella* infection and undulent fever in man. London: Oxford University Press, 1960.

Damon SR, Scruggs JH, Parker EB. Brucellosis as an occupational hazard. J Am Vet Med Assoc 1950; 117: 39-40.

Davies JE. Chronic brucellosis in general practice. Br Med J 1957; 2: 1082-1087.

Davos DE, Cargill CF, Kyrkou MR, Jamieson JA, Rich GE. Outbreak of brucellosis at a south Australian abattoir. II. Epidemiological investigations. Med J Aust 1981; 2: 657-660.

Editorial. Controlling brucellosis. Can J Public Health 1950; 41: 337-338.

Editorial. Brucellosis. Br Med J 1981; 282: 1180.

Editorial. How does *Brucella abortus* infect human beings? Lancet 1983; 2: 1180.

Elberg SS, Henderson DW. Respiratory pathogenicity of *Brucella*. J Infect Dis 1948; 82: 302-306.

Elkington GW, Wilson GS, Taylor J, Fulton F. A mild epidemic of undulent fever in a boys' school due to drinking raw milk. Br Med J 1940; 1: 477-478.

Eze EN. *Brucella* hygroma fluid: possible veterinary and human public health hazards. Bull Anim Health Prod Afr 1981; 29: 193-195.

Fincham RW, Sahs AL, Joynt RJ. Protean manifestations of nervous system brucellosis. J Am Med Assoc 1963; 184: 269-275.

Fish NA. Brucellosis. Can J Public Health 1964; 55: 80-83.

Flynn MP. Human clinical bovine-type brucellosis not derived from milk. Public Health 1983; 97: 149-157.

Fox MD, Kaufmann AF. From the Center for Disease Control: brucellosis in the United States, 1965-1974. J Infect Dis 1977; 136: 312-316.

Galbraith NS, Pusey JJ. Milkborne infectious diseases in England and Wales, 1938-1982. In: Freed DLJ, ed. Health Hazards of Milk. London: Bailliere Tindal, 1984: 27-59.

George JTA, Payne DJH. Tuberculosis from T.T. milk, with a note on the frequency of Brucella abortus in consumer milk. Month Bull Min Health Publ Health Lab Serv 1961; 20: 99-102.

Gilbert GL, Beaton CP, Forsyth JRI, Bell CO. An epidemiological survey of human brucellosis in three Victorian abattoirs. Med J Aust 1980: 1: 482-486.

Gilman HL, Dahlberg AC, Marquardt JC. The occurrence and survival of Brucella abortus in cheddar and limburger cheeses. J Dairy Sci 1946; 29: 71-85.

Gilman HL, Marquardt JC. The occurrence and survival of Brucella abortus in Italian cheese curd made from raw and pasteurized milk. J Milk Food Technol 1951; 14: 55-56.

Glasgow MMS. Brucellosis of the spine. Br J Surg 1976; 63: 283-288.

Goodhart GL, Zakem JF, Collins WC, Meyer JD. Brucellosis of the spine. Report of a patient with bilateral paraspinal abscesses. Spine 1987; 12: 414-416.

Grant GH, Stote CL. Rupture of the heart as a result of Brucella abortus endocarditis. Br Med J 1953; 1: 914-916.

Gulasekharam J. Illness following accidental self-inoculation of Brucella abortus strain 19 vaccine. Med J Aust 1970; 2: 642-643.

Harkness TGS. Brucella abortus endocarditis (letter). Br Med J 1936; 1: 722.

Hart FD, Morgan A, Lacey B. Brucella abortus endocarditis. Br Med J 1951; 1: 1048-1053.

Harvey WA. Pulmonary brucellosis. Ann Int Med 1948; 28: 768-781.

Held JR, Bauer H, West RL. Effect of eradicating brucellosis in cattle on incidence of human cases. Public Health Rep 1958; 73: 1096-1100.

Henderson RJ. An outbreak of undulent fever in Worcestershire. Month Bull Min Health Publ Health Lab Serv 1964; 23: 34-40.

Henderson RJ, Hill DM. Subclinical Brucella infection in man. Br Med J 1972; 3: 154-156.

Hendricks SL, Borts IH, Heeren RH, Hausler WJ, Held JR. Brucellosis outbreak in an Iowa packing house. Am J Public Health 1962; 52: 1166-1178.

Hendricks SL, Meyer ME. Brucellosis. In: Hubbert WT, McCulloch, Schnurrenberger PR, eds. Diseases Transmitted from Animals to Man. 6th Ed. Springfield: Charles C. Thomas, 1975: 10-32.

Hewlett JS, Ernstene AC. *Brucella abortus* infection of the gall bladder treated with streptomycin. Cleveland Clin Q 1947; 14: 258-263.

Hunt AC, Bothwell PW. Histological findings in human brucellosis. J Clin Pathol 1967; 20: 267-272.

Isaac AG. Orchitis and epididymitis due to undulent fever. J Urol 1938; 40: 201-207.

Ivanova VI. [Survival of *Brucella* in salted and frozen meat.] Trudy vsesoyuz Inst vet Sanit 1960; 17: 76-81. Abstract #699 in Vet Bull 1961; 32: 140.

Jamieson A, Rich GE, Kyrku MR, Cargill CF, Davos DE. Outbreak of brucellosis at a south Australian abattoir. Med J Aust 1981; 2: 593-596.

Joffe B, Diamond MT. Brucellosis due to self-inoculation. Ann Intern Med 1966; 65: 564-565.

Jordan FC. Brucellosis in industry. Ind Med 1948; 17: 176-180.

Kaufmann AF, Fox MD, Boyce JM, Anderson DC, Potter ME, Martone WJ, Patton CM. Airborne spread of brucellosis. Ann NY Acad Sci 1980; 353: 105-114.

Keane CT. Clinical and laboratory diagnosis of human brucellosis. Ir Vet J 1982; 36: 155-158.

Kelly PJ, Martin WJ, Schirger A, Weed LA. Brucellosis of the bones and joints. Experience with thirty-six patients. J Am Med Assoc 1960; 174: 347-353.

Kerr WR, Coughlin JD, Payne DJH, Robertson L. Chronic brucellosis in the practicing veterinary surgeon -- discussion. Vet Rec 1966; 79: 602-608.

Leresche E, Depres P, Valette H. Quelque aspects des brucelloses dans l'inspection des viandes. [Some aspects of brucellosis in meat inspection.] Schweiz Arch Tierheilk 1957; 99: 440-446.

Levine MG. Brucellosis in packing house workers. J Ind Hyg 1943; 25: 451-452.

MacDonald RD. Acute empyema with Brucella abortus as the primary causative agent. J Thorac Surg 1939; 9: 92-93.

Magoffin RL, Kabler P, Spink WW, Fleming D. An epidemiologic study of brucellosis in Minnesota. Public Health Rep 1949; 64: 1021-1043.

Martinez de Cortinez LM, Stefanini de Guzman AM, Puig de Centorbi O. Brucellosis survey in personnel of an abattoir in San Luis, Argentina. Rev Argent Microbiol 1986; 18: 63-68.

Matyas Z, Fujikura T. Brucellosis as a world problem. Dev Biol Stand 1984; 56: 3-20.

McCullough NB. Human brucellosis with special reference to the disease in the United States. Ann NY Acad Sci 1958; 70: 541-556.

McCullough NB. Medical care following accidental injection of Brucella abortus, strain 19, in man. J Am Vet Med Assoc 1963; 143: 617-618.

McDevitt DG. Symptomatology of chronic brucellosis. Br J Ind Med 1973; 30: 385-389.

Menton J. Brucellosis in man and animals in Staffordshire. Br Med J 1937; 2: 1273-1275.

Meyer KF, Eddie B. Laboratory infections due to Brucella. J Infect Dis 1941; 68: 24-32.

Montes J, Rodriguez MA, Martin T, Martin F. Laboratory-acquired meningitis caused by Brucella abortus strain 19. J Infect Dis 1986; 154: 915-916.

Morales-Otero, P. Brucella abortus in Puerto Rico. Peurto Rico J Publ Health Trop Med 1930; 6: 3-88.

Nelson-Jones, A. Neurological complications of undulent fever. The clinical picture. Lancet 1951; 260: 495-498.

Nicols E. Meningo-encephalitis due to brucellosis with the report of a case in which B. abortus was recovered from the cerebrospinal fluid, and a review of the literature. Ann Intern Med 1951; 35: 673-693.

Pal M, Jain HS. Anthropozoonotic role of Brucella abortus. Int J Zoonoses 1986; 13: 246-248.

Pascual J, Combarros O, Polo JM, Berciano J. Localized CNS brucellosis: report of seven cases. Acta Neurol Scand 1988; 78: 282-289.

Pazderka E, Jones JW. Brucella abortus endocarditis -- successful treatment of an infected aortic valve. Arch Intern Med 1982; 142: 1567-1568.

Peelman J, Dekeyser P. De verspreiding van de Brucella-infectie by vlaamse werknemers professioneel in contact met runderen. [Occurrence of brucellosis among Flemish workers in occupational contact with cattle.] Vlaams Diergeneeskundig Tijdschrift 1987; 56: 314-323.

Peery TM, Evans JM. Brucellosis and heart disease. III. Chronic valvular heart disease following nonfatal brucellosis. Ann Intern Med 1958; 49: 568-579.

Peery TM, Belter LF. Brucellosis and heart disease. II. Fatal brucellosis: a review of the literature and report of new cases. Am J Pathol 1960; 36: 673-697.

Pivnick H, Worton H, Smith DLT, Barnum D. Infection of veterinarians in Ontario by Brucella abortus strain 19. Can J Public Health 1966; 57: 225-231.

Prost E. [Brucellosis and food hygiene.] Mh VetMed 1963; 18: 715-718. Abstract #1555 in Vet Bull 1964; 34: 230.

Quintin TJ, Stalker MR. Endocarditis due to Brucella abortus. Can Med Assoc J 1946; 55: 50-52.

Ray WC. Brucellosis (due to Brucella suis and B. abortus). In: Steele JH, ed. CRC Handbook Series in Zoonoses. Section A: Bacterial, Rickettsial and Mycotic Diseases. Vol I. Boca Raton, Fla: CRC Press Inc, 1979: 99-183.

Rennie JK, Young CJ. Malignant endocarditis due to Brucella abortus. Br Med J 1936; 1: 412-413.

Revich SJ, Walker AW, Pivnick H. Human infection by Brucella abortus strain 19. Can J Public Health 1961; 52: 285-289.

Reyes Knoke, MA. Serological prevalence of brucellosis in exposed occupational groups in El Salvador. Rev Inst Med Res 1979; 3: 97-103.

Sacks N, Van Rensburg AJ. Clinical aspects of chronic brucellosis. S Afr Med J 1976; 50: 725-728.

Sadler WW. Present evidence on the role of meat in the epidemiology of human brucellosis. Am J Public Health 1960; 50: 504-514.

Sadusk JF, Born JL. Brucellosis in man resulting from Brucella abortus (strain 19) vaccine. J Am Med Assoc 1957; 164: 1325-1328

Sanderson NV, Karn RH, LeGrow WR, Raymond OC. A brucellosis survey in Brant County, Ontario. Can J Public Health 1951; 42: 295-298.

Schnurrenberger PR, Martin RJ, Wactor PR, Jelly GG. Brucellosis in an Illinois abattoir. Arch Environ Health 1972; 24: 337-341. Second Forum in Microbiology. *Brucella* and brucellosis: an update. Ann Inst Pasteur Microbiol 1987; 138: 67-144.

Smith CC. The treatment of human brucellosis. Scot Med J 1976; 21: 132-133.

Smith CC, Porter IA, Swapp GH. Mid-trimester abortion due to infection with *Brucella abortus*. J Infect Dis 1982; 5: 297-299.

Snell E. Brucellosis in Manitoba. Can J Public Health 1964; 55: 247-250.

Spink WW. Histopathology of the liver in human brucellosis. J Lab Clin Med 1949; 34: 40-58.

Spink WW. Encephalomeningitis due to *Brucella abortus*. Trans Am Clin Climat Assoc 1949; 61: 121.

Spink WW. The Nature of Brucellosis. Minneapolis: University of Minnesota Press, 1956.

Spink WW. Host-parasite relationship in brucellosis. Lancet 1964; 2: 161-164.

Steele JH, Hendricks SL, Barr R, Parker RL. Brucellosis in the United States, 1970. Report of Subcommittee on Public Health. Arch Environ Health 1972; 25: 66-72.

Stoenner HG, Jenkins AA, Branmhall EH. Studies of brucellosis in Utah. J Infect Dis 1949; 85: 213-224.

Syrjamaki C. *Brucella abortus* endocarditis following ingestion of cow's blood. Nebraska Med J 1984; 69: 141-142.

Taylor JP, Perdue JN. The changing epidemiology of human brucellosis in Texas, U.S.A., 1977-1986. Am J Epidemiol 1989; 130: 160-165.

Tessaro SV, Forbes LB. *Brucella suis* biotype 4: a case of granulomatous nephritis in a barren ground caribou (*Rangifer tarandus groenlandicus* L.) with a review of the distribution of rangiferine brucellosis in Canada. J Wildl Dis 1986; 22: 479-483.

Tessaro SV. A descriptive and epizootiologic study of brucellosis and tuberculosis in bison in northern Canada. Ph.D.

Thesis, University of Saskatchewan, 1987. xxi + 320 pp.

Torres-Rojas J, Taddonio RF, Sanders CV. Spondylitis caused by *Brucella abortus*. South Med J 1979; 72: 1166-1169.

Uche UE, Agbo JAC. Bacterial isolates from Nsukka meat market: zoonotic appraisal. Int J Zoonoses 1985; 12: 105-110.

Wallis HRE. Brucellosis in children. Br Med J 1957; 1: 617-621.

Weed LA, Dahlin DC, Pugh DG, Ivins JC. *Brucella* in tissues removed at surgery. Am J Clin Pathol 1952; 22: 10-21.

Weissenborn K, Weihler S, Malin JP. Meningoencephalitis owing to *Brucella abortus* infection. Deut Med Wochenschr 1987; 112: 57-59.

Welsby PD, Smith CC. Brucellosis: the current position. Br J Hosp Med 1978; 19: 20-27.

White PC, Baker EF, Roth AJ, Williams WJ, Stephens TS. Brucellosis in a Virginia meat-packing plant. Arch Environ Health 1974; 28: 263-271.

Williams B. Brucellosis. Practitioner 1982; 226: 1507-1517.

Williams E. A new look at infectious diseases: brucellosis. Br Med J 1973; 1: 791-793.

Williams E. Brucellosis in humans: its diagnosis and treatment. Acta Pathol Microbiol Immunol Scand 1988; Suppl 3: 21-25.

Williams RK, Crossley K. Acute and chronic hepatic involvement of brucellosis. Gastroenterol 1982; 83: 455-458.

Willoughby EW, Lambert JA, Braan-Stro S. Oligoclonal IgG with anti-*Brucella* specificity in CSF in chronic *Brucella* meningitis with myeloradiculopathy. Can J Neurol Sci 1986; 13: 380.

Wilson GS. Vaccination against bovine contagious abortion and the relationship of this disease to undulent fever in man. Vet Rec 1932; 12: 1226.

Wilson GS. Latent *Brucella* infections in veterinarians. Vet Rec 1932; 12: 1240-1245.

Wise RI. Brucellosis in the United States: past, present and future. J Am Med Assoc 1980; 244: 2318-2322.

Wise RI. Foodborne diseases: brucellosis. In: Rechcigl M, ed. CRC Handbook of Foodborne Diseases of Biological Origin. Boca

Raton, Fla: CRC Press Inc, 1983: 317-322.

Woodson PD. Brucellosis: a study of an occupational hazard and public health care problem. Dis Abst Int B 1982; 43: 106.

World Health Organization. A guide to the diagnosis, treatment, and prevention of human brucellosis. Geneva: World Health Organization, 1981. Document VPH/81.31 71 pp.

Wright PW. Brucellosis. Am Fam Physician 1987; 35: 155-159.

Young EJ. Human brucellosis. Rev Infect Dis 1983; 5: 821-842.

Young EJ. Brucellosis: a model zoonosis in developing countries. Acta Pathol Microbiol Immunol Scand 1988; Suppl 3: 17-20.

Literature: (B) Zoonotic aspects of *Mycobacterium bovis*

Baldwin JH. Pulmonary bovine tuberculosis in an owner and in his dairy herd. Cornell Vet 1968; 58: 81-87.

Bang O. Om forholdet mellem den bovine og humane tuberkulose. [Relation between bovine and human tuberculosis.] Medlemsbl danske Dyrlaegeforen 1935; 18 (Suppl): 2-9.

Barrera L. Bovine mycobacteriosis and tuberculosis in humans in Argentina (1982-1984). Rev Argent Tuberc Enferm Pulm Salud Publica 1985; 46: 45-55.

Barrie JD, Bruce LG. Human infections with bovine tuberculosis in the west of Scotland, 1963-1965. Scot Med J 1966; 11: 436-439.

Bashe WJ, Schnurrenburger PR, Miller RR. Relationship between human and bovine tuberculosis in Ohio. An epidemiologic study. Ohio Med J 1962; 58: 46-48.

Beattie M, Nicewonger R. Bovine tubercle bacilli in sputum. Am Rev Tuberc 1942; 45: 586-588.

Behrend H. Cattle tuberculosis and tuberculous meat. London: F. Calder-Turner, 1893.

Black H. The association of tuberculosis in man with a recurrent infection in a dairy herd. NZ Vet J 1972; 20: 14-15.

Blacklock JWS. A study of tuberculous disease in infancy and childhood, with particular reference to the primary sites of infection. Br J Tuberc 1935; 29: 69-90.

Blacklock JWS, Griffin MA. Tuberculous meningitis in children. J Pathol Bacteriol 1935; 40: 489-502.

Blagodarnyi YA, Bekmagambetova ZZ, Blonskaya LI, Sidorkina EV, Krivtsova AE, Aleeva AA, Tulegenov AT, Alimbekova OA. Tuberkulez u zhivotnovodov, vyzvannyi mikobakteriyami bych'ego tipa. [Tuberculosis among agricultural workers caused by bovine type Mycobacterium tuberculosis.] Problemy Tuberkuleza 1975; No 10: 72-75.

Blegvad O. Fortsatte undersogelser over conjunctivaltuberculosen. [Investigations on conjunctival tuberculosis in man.] Medlemsbl danske Dyrlaegeforen 1935; 18 (Suppl): 45-51.

Boquet A. Caracteres distinctifs du bacille bovin et role de ce germe dans l'infection tuberculeuse de l'homme. [Distinctive characteristics of the bovine type of the tubercle bacillus and the role of this organism in human tuberculosis.] Rev Immunol 1939; 5: 321-349.

Bordley J, Baylor JW. Prognosis in cases of tuberculosis of the tonsils, adenoids and cervical lymph nodes. Bull Johns Hopkins Hosp 1938; 63: 132-153.

Bouvier G. Transmission possible de la Tuberculose et de la Brucellose du gibier a l'homme et aux animaux domestiques et sauvages. [Possible transmission of tuberculosis and brucellosis from game animals to man and domestic animals.] Bull Off Int Epizoot 1963; 59: 433-436.

Brown MH. The incidence of the bovine bacillus in lesions found in man. Can Publ Health J 1936; 27: 88-89.

Bruce LG. The incidence of genitourinary tuberculosis in the western region of Scotland. Br J Urol 1970; 42: 637-641.

Calmette A. L'infection bacillaire et la tuberculose chez l'homme et chez les animaux. [Bacterial infections and tuberculosis in man and animals.] 4th Ed. Paris: Masson, 1936.

Cameron AE. Bovine tuberculosis in Canada. Can Publ Health J 1938; 29: 262-265.

Chievitz O. Er der forskel paa det kliniske billede af den humane og bovine infektion saerlig ved kirurgisk og glandeltuberkulose. [Differentiation of human and bovine types of infection especially in surgical and gland tuberculosis.] Medlemsbl danske Dyrlaegeforen (Suppl) 1935; 18: 37-44.

Christensen AC. Genitourinary tuberculosis: review of 102 cases. Medicine 1974; 53: 377-383.

Clarke BR. Causes and prevention of tuberculosis. Edinburgh: E. and S. Livingstone, 1952: 187-202.

Collins CH. Is bovine, atypical or resistant tuberculosis a problem? Ir Med J 1987; 80: 66-67.

Collins CH, Grange JM. The bovine tubercle bacillus. J Appl Bacteriol 1983; 55: 13-29.

Collins CH, Grange JM. Zoonotic implications of Mycobacterium bovis infection. Ir Vet J 1987; 41: 363-366.

Collins CH, Yates MD, Grange JM. A study of bovine strains of Mycobacterium tuberculosis isolated from humans in South East England: 1977-1979. Tubercle 1981; 62: 113-116.

Collins CH, Yates MD, Grange JM. Human-to-human spread of infection by Mycobacterium bovis (letter). Tubercle 1982; 63: 143-144.

Cumming WM, Forster WM. Pulmonary tuberculosis with the bovine type of the bacillus in sputum. J Pathol Bacteriol 1933; 36: 153-168.

Cutbill LJ, Lynn A. Pulmonary tuberculosis of bovine origin with notes on bovine infections in three families. Br Med J 1944; 1: 283-285.

Dalling T, Gloyne SR. Discussion on the control of diseases of cattle inimical to man; tuberculosis. Proc R Soc Med 1942; 35: 469-478.

Damsker B, Bottone EJ, Schneierson SS. Human infections with Mycobacterium bovis. Am Rev Resp Dis 1974; 110: 446-449.

Davies PD, Humphries MJ, Byfield SP. Bone and joint tuberculosis. A survey of notifications in England and Wales. J Bone Joint Surg 1984; 60: 326-330.

deGara PF. Bovine tuberculosis: its incidence in bone, joint and cervical lymph node lesions in Italy. Am Rev Tuberc 1942; 45: 576-585.

Dreesen DW, Wood AR. A human case of Mycobacterium bovis infection in Georgia. Am Rev Resp Dis 1970; 101: 289-292.

Editorial. The milk problem. Lancet 1937; 233: 143.

Editorial. That long last mile in bovine tuberculosis eradication. J Am Med Assoc 1954; 124: 319-320.

Editorial. Bovine tuberculosis. Tubercle 1955; 36: 327.

Enarson DH, Ashley MJ, Grzybowski S, Ostapkowicz E, Dorken E. Non-respiratory tuberculosis in Canada. Epidemiology and bacteriologic features. Am J Epidemiol 1980; 112: 341-351.

Feldman WH. Animal tuberculosis and its relationship to the disease in man. Ann NY Acad Sci 1947; 48: 469-505.

Francis J. Control of infection with the bovine tubercle bacillus. Lancet 1950; 1: 34-39.

Francis J. Tuberculosis in animals and man. A study in comparative pathology. London: Cassell, 1958.

Francis J. Tuberculosis of animals and its transmission to man. Vet Rec 1959; 71: 474-476.

Francis J. The work of the Royal Commission. Tubercle 1959; 40: 124-132.

Francis J. The economic importance of bovine tuberculosis. In: First International Seminar on Bovine Tuberculosis for the Americas. Santiago, Chile. Washington, DC: World Health Organization and Pan American Health Organization, 1970: 101-102.

Francis J. Very small public health risk from flesh of tuberculous cattle. Aust Vet J 1973; 49: 496-497.

Fraser J. The relative prevalence of human and bovine types of tubercle bacilli in bone and joint tuberculosis in children. J Exp Med 1912; 16: 432

Freese H. Die Dedeutung des Typus bovinus des Tuberkelbakteriums fur die menschliche Tuberkulose. [The importance of bovine type tubercle bacilli in human tuberculosis.] Die Rindertuberkulose 1955; 4: 233-247.

Gaiger SH. Bovine tuberculosis and its relation to the disease in man. J Min Agr Lond 1932; 39: 17-23.

Galbraith NS, Pusey JJ. Milk-borne infectious diseases in England and Wales, 1938-1982. In: Freed DLJ, ed. Health Hazards of Milk. London: Bailliere Tindall, 1984: 27-59.

Gernez C. Role of tuberculous bacilli of the bovine type in tuberculous infection of man. Medicine (Baltimore) 1939; 20: 373-390.

Gittes RF, Young RH. A 54-year-old woman with a contracted urinary bladder and hematuria. N Engl J Med 1987; 316: 676-681.

George TJA, Payne DJH. Tuberculosis from tuberculin tested milk, with a note on the frequency of *Brucella abortus* in consumer milk. Month Bull Min Health 1969; 20: 99-102.

Goerttler V, Weber E. Tuberkulose als Ursache humaner Tuberkulose. Zusammengestellt aus dem internationalen Schrifttum bis 1952. [Tuberculosis in cattle as a cause of tuberculosis in human beings. A review of the international literature up to 1952.] Die Rindertuberkulose 1954; 3: 29-52, 54-78.

Goette DK, Jacobson KW, Doty RD. Primary inoculation tuberculosis of the skin. Arch Dermatol 1978; 114: 567-569.

Gosling R, Montanus J. Direct cultivation of tubercle bacilli from spinal fluids: occurrence of human and bovine types. J Med Res 1924; 44: 513-519.

Grange JM, Collins C, Yates M. Bacteriological survey of tuberculous lymphadenitis in south-east England. J Epidemiol Community Health 1982; 36: 157-161.

Grange JM, Collins CH. Bovine tubercle bacilli and disease in animals and man. Epidemiol Infect 1987; 99: 221-234.

Griffith AS. The types of tubercle bacilli occurring in the sputum of phthisical persons. J Pathol Bacteriol 1930; 33: 1145-1169.

Griffith AS. The relative incidence of human and bovine tubercle bacilli in tuberculous meningitis in England. J Pathol Bacteriol 1932; 35: 97-102.

Griffith AS. Human tuberculosis of bovine origin. Edinburgh Med J 1932; 39: 177-189.

Griffith AS. The bovine tubercle bacillus in human tuberculosis. Br Med J 1932; 2: 501-503.

Griffith AS. Incidence of human and bovine bacilli in tuberculous meningitis. Lancet 1934; 226: 1382-1387.

Griffith AS. Bovine tuberculosis in man. Tubercle 1937; 18: 529-543.

Griffith AS. Bovine tuberculosis in the human subject. Proc R Soc Med 1938; 31: 1208-1212.

Griffith AS, Monro WT. The relative incidence of human and bovine types of tubercle bacilli in human tuberculosis in Scotland. J Pathol Bacteriol 1932; 35 (I): 271-281.

Griffith AS, Monro WT. Phthisis pulmonis due to the bovine type of tubercle bacillus. Lancet 1933; 224: 399-403.

Griffith AS, Monro WT. Family tuberculosis due to bovine tubercle bacilli. Br Med J 1935; 3: 147-150.

Griffith AS, Monro WT. Human pulmonary tuberculosis of bovine origin in Great Britain. J Hyg 1944; 43: 229-240.

Griffith AS, Summers GJ. Human and bovine infections in bone and joint tuberculosis. Lancet 1933; 224: 875-876.

Habib NI, Warring FD. A fatal case of infection due to Mycobacterium bovis. Am Rev Resp Dis 1966; 93: 804-810.

Hedvall E. Bovine tuberculosis in man. A clinical study of bovine tuberculosis, especially pulmonary tuberculosis in the southernmost part of Sweden. Acta Med Scand 1942; Suppl 35: 1-196.

Hermansson KA. Foreligger risk for besiktningsveterinar att under sitrt pa offenligt slakthus eller kontrollslakteri bliva infekterad med tuberkelbakterier? [Are veterinary meat inspectors in slaughter houses at risk of contracting tuberculosis?] Skand VetTidskr 1939; 29: 926-933.

Hilton G. Discussion on bovine tuberculosis in Canada. Bull Can Tuberc Assoc 1929/30; 8 (Suppl): 12.

Hilton G. Eradication of tuberculosis. Can Vet J 1985; 26: 92.

Holdiness MR. Mycobacterium bovis infection (letter). Arch Intern Med 1985; 145: 1930.

Horne NW. Problems of tuberculosis in decline (editorial). Br Med J 1984; 288: 1249-1251.

Hublart M, Moine G. La tuberculose humaine a bacille bovin dans le monde. [Human tuberculosis caused by the bovine bacillus in the world.] Bull Acad Vet 1969; 42: 53.

Huitema H. Tuberculosis in animals other than cattle, domesticated and wild: its relation to bovine tuberculosis eradication and its public health significance. In First International Seminar on Bovine Tuberculosis for the Americas. Santiago, Chile. Washington, DC: World Health Organization and Pan American Health Organization, 1970: 79-87.

Iden DL, Rogers RS, Scroecer AL. Papulonecrotic tuberculid secondary to Mycobacterium bovis. Arch Dermatol 1978; 114: 564-566.

Idrison A, Schnurrenberger PR. Public health significance of bovine tuberculosis in four northern states of Nigeria. A mycobacteriologic study. Nigerian Med 1977; 7: 384-387.

Jensen KA. Bovine tuberculosis in man and cattle. WHO Monogr Ser 1953; 19: 11-24.

Jensen KA, Kiaer I. Studies on types of tubercle bacilli isolated from man; mixed infections with human and bovine tubercle bacilli. Acta tuberc Scand 1938; 12: 105-200.

Jensen KA, Lester V. Studies on types of tubercle bacilli isolated from man; supplementary studies on cases described in report. V. Some new cases of mixed infections. Acta tuberc Scand 1941; 15: 15-46.

Jensen KA, Lester V, Tolderlund K. Frequency of bovine infection among tuberculous patients in Denmark. Acta tuberc Scand 1940; 14: 125-157.

Jones PG, Silva J. *Mycobacterium bovis* meningitis. J Am Med Assoc 1982; 247: 2270-2271.

Jorgensen JB, Husum PT, Haarbo K. Kvaegtuberkulose. Et besaetningsudbrud med et menneske som smittekilde. [Bovine tuberculosis. An outbreak from a human source.] Dansk Veterinaertidsskrift 1985; 68: 793-796.

Karlson AG, Carr DT. Tuberculosis caused by *Mycobacterium bovis*: report of six cases. Ann Intern Med 1970; 73: 979-983.

Kataria YP. Observations on human infection with *Mycobacterium bovis*. Tubercle 1969; 50: 14-21.

Kleeberg HH. Tuberculosis and other mycobacterioses. In: Hubbert WT, McCulloch WF, Schnurrenberger PR, eds. Diseases Transmitted from Animals to Man. 6th Ed. Springfield: Charles C. Thomas, 1975: 303-360.

Kleeberg HH. Human tuberculosis of bovine origin in relation to public health. Rev Sci Techn Off Int Epizoot 1984; 3: 11-32.

Kleinschmidt H. Tuberculosis caused by bovine mycobacteria. Tuberculosearzt 1958; 12: 471-476.

Konyha LD, Himes EM, Thoen CO. Bovine tuberculosis. In: Steele JH, ed. CRC Handbook Series in Zoonoses. Section A: Bacterial, Rickettsial and Mycotic Diseases. Vol II. Boca Raton, Fla: CRC Press Inc, 1979: 109-159.

Kubin M, Heralt Z, Morongova I, Ruzhova R, Viznerova A. Zwei Falle der wahrscheinlichen interhumanen Ubertragung von

Mycobacterium bovis. [Two cases of probable human-to-human transmission of *Mycobacterium bovis*.] Zeitschrift fur Erkrankungen der Atmungsorgane 1984; 163: 285-291.

Lange B. Untersuchungen uber den Typus der Tuberkelbacillen bei Lupus vulgaris. [Types of tubercle bacilli in lupus vulgaris.] Z Hyg InfekKr 1937; 119: 166-185.

Legge TM, Sessions H. Cattle tuberculosis: a practical guide to the farmer, butcher and meat inspector. London: Balliere, Tindall and Cox, 1898.

Lesne E, Saenz A, Salembiez M, Costil L. Role du bacille bovin dans l'etiologie de la meningite tuberculeuse de l'enfant. [The role of the bovine tubercle bacillus in the etiology of tuberculous meningitis in children.] Bull Acad Med Paris 1936; 116: 373-382.

Lesslie IW. Cross-infections with mycobacteria between animals and man. Bull Int Union Tuberc 1968; 41: 285-288.

Lesslie IW, Magnus K, Stewart CJ. The prevalence of bovine type tuberculous infection in man in the English rural population. Tubercle 1972; 53: 198-204.

Lethem WA. Bovine tuberculosis. Month Bull Min Health Publ Health Lab Serv 1946; 5: 80-81.

Lethem WA. Bovine tuberculosis. Month Bull Min Health Emerg Public Health Lab Serv 1946; 5: 80-81.

Lethem WA. Milk-borne tuberculosis, 1921-1953. Month Bull Min Health 1955; 14: 144-145.

Lockhead DC. Bovine tuberculosis in humans. Proc 46th Meet US Livest Sanit Assoc, 1943: 75-78.

Magnus K. Epidemiological basis of tuberculosis eradication. 3. Risk of pulmonary tuberculosis after human and bovine infection. Bull WHO 1966; 35: 483-508.

Magnus K. Epidemiological basis of tuberculosis eradication. 5. Frequency of pulmonary calcifications after human and bovine infections. Bull WHO 1967; 36: 703-718.

Magnusson H. The relationship between bovine and human tuberculosis from the veterinary point of view. Acta Med Scand 1942; Suppl 135: 201-239.

McDougall JB. Tuberculosis. A global study in social pathology. London: E. and S. Livingstone, 1949: 376-382.

McGee GS. Gastrointestinal tuberculosis: resurgence of an old pathogen. Am Surg 1989; 55: 16-20.

Meissner G. Die bovine Tuberkulose des Menschen Wahrend und nach Beendigung der Aktion zur Tilgung der Rindertuberkulose. [Bovine tuberculosis in man before and after the eradication of tuberculosis in cattle.] Prax Pneumol 1974; 28: 123-128.

Meissner G, Schroder KH. Bovine tuberculosis in man and its correlation with bovine cattle tuberculosis. Bull Int Union Tuberc 1974; 49: 145-148.

Mitchell AP. Report on the infection of children with the bovine tubercle bacillus. Br Med J 1914; 1: 125

Mushatt C. Non-pulmonary tuberculosis caused by the bovine type of tubercle bacillus in children in Eire. J Hyg 1940; 40: 396-405.

Myers JA. Tuberculosis in animals and man. J Am Med Assoc 1932; 80: 914-920.

Myers JA, Steele JH. Bovine tuberculosis control in man and animals. St. Louis: W.H. Green, 1969.

Novick N. The incidence of bovine infection in tuberculous meningitis. J Med Res 1920; 41: 239-246.

O'Donohue WJ, Bedi S, Bittner MJ, Preheim LC. Short-course chemotherapy for pulmonary infection due to Mycobacterium bovis. Arch Intern Med 1985; 145: 703-705.

Pagel W, Simmonds FAH, MacDonald N. Pulmonary tuberculosis: pathology, diagnosis, management and prevention. London: Oxford University Press, 1953.

Park WH. Relation of milk to tuberculosis. Am Rev Tuberc 1927; 15: 399-418.

Park WH, Krumwieder C. The relative importance of the bovine and human types of tubercle bacilli in different forms of human tuberculosis. J Med Res 1910; 23: 205-268.

People's League of Health. Report of a special committee appointed by the People's League of Health Inc. to make a survey of tuberculosis of bovine origin in Great Britain. London: The People's League of Health, 1932.

Pitchenik AE. Mycobacterial disease: epidemiology, diagnosis, treatment, and prevention. Clin Chest Med 1988; 9: 425-441.

Plum N. Mennesketuberkulose -- Kvaegtuberkulose. [Human tuberculosis -- bovine tuberculosis.] Skand VetTidskr 1935; 25: 121-132.

Price RM. Bovine tuberculosis in its relation to infection in children. Bull Can Tuberc Assoc 1929/30; 8 (Suppl): 6

Price RM. Types of tubercle bacilli in human tuberculosis. Can J Res 1932; 7: 606-616.

Price RM. Summary of study of types of tubercle bacilli isolated from human lesions. Am Rev Tuberc 1932; 25: 383-392.

Price RM. Bovine tuberculosis in children. Can Public Health J 1938; 29: 251-254.

Price RM. The bovine tubercle bacillus in human tuberculosis. Am J Med Sci 1939; 197: 411-427.

Pritchard DG. A century of bovine tuberculosis 1888-1988: conquest and controversy. J Comp Pathol 1988; 99: 357-399.

Ravenel MP. Transmission of animal diseases to man through milk. Can Public Health J 1941; 32: 174-182.

Reilly LV. Human tuberculosis of bovine origin in Northern Ireland. J Hyg 1950; 48: 464-471.

Rich AR. The pathogenesis of tuberculosis. 3rd Ed. Springfield: Charles C. Thomas, 1951.

Ritchie J. The eradication of bovine tuberculosis and its importance to man and beast. Conquest 1964; 52: 3-12.

Roberts, T. A retrospective assessment of human health protection benefits from removal of tuberculous beef. J Food Protect 1986; 49: 293-298.

Ruys AC. On tuberculosis in man due to the bovine type of the tubercle bacillus in the Netherlands. Tubercle 1939; 20: 556-560.

Saenz A, Fatio DM. Etude etiologique et bacteriologique de deux cas de synovite tuberculeuse a bacille bovin. [Etiologic and bacteriologic study of two cases of tuberculous synovitis caused by the bovine type of tubercle bacilli.] C R Soc Biol Paris 1938; 127: 1418-1421.

Savage WG. The prevention of human tuberculosis of bovine origin. London: Macmillan, 1929.

Savage WG. The Mitchell Lecture on human tuberculosis of bovine origin. Br Med J 1933; 2: 905-910.

Schmeidel A. Development and present state of bovine tuberculosis in man. Bull Int Union Tuberc 1968; 40: 1-31.

Schonfeld JK. Human-to-human spread of infection by *Mycobacterium bovis* (letter). Tubercle 1982; 63: 143-144.

Sigurdsson J. Studies on the risk of infection with bovine tuberculosis to the rural population. Acta tuberc Scand 1945; Suppl 15: 1-250.

Simor AE, Patterson C. Disseminated *Mycobacterium bovis* infection in an elderly patient. Diagn Microbiol Infect Dis 1987; 7: 149-153.

Sjorgen I, Sutherland I. Studies of tuberculosis in man in relation to infection in cattle. Tubercle 1974; 56: 113-127.

Smith HR. Bovine tuberculosis in the United States and its effect on public health. Am Rev Tuberc 1944; 50: 520-533.

Smith, T. A comparative study of bovine tubercle bacilli and of human bacilli from sputum. J Exp Med 1898; 3: 451-511.

Smith, T. Studies in mammalian tubercle bacilli. III. Description of a bovine bacillus from the human body. A culture tuest for distinguishing the human from the bovine type of bacilli. J Med Res 1905; 13: 253-300.

Sternfeld L. A human case of *Mycobacterium bovis* in Massachusetts. In: CDC Veterinary Public Health Notes. Atlanta: National Communicable Disease Center, 1970: 3.

Stoller JK. Late recurrence of *Mycobacterium bovis* genitourinary tuberculosis: case report and review of literature. J Urol 1985; 134: 565-566.

Stumpff CD. Epidemiological study of the outbreak of bovine TB in confined elk herds. Proc US Anim Health Assoc 1982; 86: 524-527.

Tessaro SV. A descriptive and epizootiologic study of brucellosis and tuberculosis in bison in northern Canada. Ph.D. Thesis, University of Saskatchewan, 1987. xxi + 320 pp.

Thoen CO. Zoonosis update: tuberculosis. J Am Vet Med Assoc 1988; 193: 1045-1048.

Tice FJ. Man, a source of bovine tuberculosis in cattle. Cornell Vet 1944; 34: 363-365.

Torning K. Bovine tuberculosis (with a case report and some remarks). Chest 1965; 47: 241-246.

Van Zwanenberg DF, Stewart CJ, Harding KM, Gray STG. Sources of tuberculous infection in an area containing bovine tuberculosis. Br Med J 1956; 1: 1464-1466.

Verne ST, Delplace Y, Cavigneaux A. Tuberculose bovin d'inoculation: maladie professionelle ou accident du travail? [Legal aspects of bovine tuberculosis in man from handling diseased carcasses and skins.] Ann Med leg 1952; 32: 304-311.

Werner VE. Transmission of tuberculosis to cattle herd from livestock attendant with renal tuberculosis. Monat fur Veterinarmed 1981; 36: 819-820.

Wigle WD, Ashley MJ, Killough EM, Cosens M. Bovine tuberculosis in humans in Ontario: the epidemiologic features of 31 active cases occurring between 1964 and 1970. Am Rev Resp Dis 1972; 106: 528-534.

Wilkins EGL, Griffiths RJ, Roberts C. Bovine tuberculosis of the skin. J Infect 1986; 12: 280-281.

Wilkins EGL, Griffiths RJ, Roberts C. Bovine variants of Mycobacterium tuberculosis isolated in Liverpool during the period 1969 to 1983 -- an epidemiological survey. Q J Med 1986; 59: 627-635.

Wilkins EGL, Griffiths RJ, Roberts C. Pulmonary tuberculosis due to Mycobacterium bovis. Thorax 1986; 41: 685-687.

Wilson GS, Blacklock JWS, Reilly LV. Non-pulmonary tuberculosis of bovine origin in Great Britain and Northern Ireland. London: The National Association for the Prevention of Tuberculosis, 1952.

Wolff K. Mycobacterial diseases: tuberculosis. In Fitzpatrick TB, Eisen AZ, Wolff F, Freedberg IM, Austen KF, eds. Dermatology in general medicine. 2nd Ed. New York: McGraw-Hill Book Co, 1979. p 1473-1492.

Worthington RW. An unusual case of bovine tuberculosis in man. J S Afr Vet Assoc 1964; 35: 390-391.

Yates MD, Grange JM. Incidence and nature of human tuberculosis due to bovine tubercle bacilli in south-east England: 1977-1987. Epidemiol Infect 1988; 101: 225-229.

Yates MD, Grange JM, Collins CH. The nature of mycobacterial disease in south-east England, 1977-1984. J Epidemiol Community Health 1986; 40: 295-300.